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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Micro-piping.

An extremely interesting memoir has recently been written by MM. L. Guillet, J. Galibourg, and M. Ballay for "Revue de Metallurgie" on intercrystalline cavities, or, to give their caption a loose translation, "micro-piping." This conception must of necessity eliminate the result as exhibited in a void in an ingot or casting, whilst insisting that the cause is the same. According to the authorities cited, it can be stated that in a general way "micro-piping" is due to the operation of the following conditions:—It is assumed that in a mould there has been cast a metal of which the temperatures at the beginning and end of the freezing range are similar in spite of the presence of pure metals, eutectics, and compounds existing in the liquid state. On contact with the walls of the mould the metal freezes and establishes in the mass a temperature gradient, decreasing from the centre to the outside. At a given moment the coldest particles reach the solidification temperature of the metal. The walls of the mould are carpeted with crystals, which grow progressively from the exterior to the interior according to the equilibrium isothermic surfaces—*solidus-liquidus*. This surface marks the separation between the solid and liquid metal. Within the volume limited by these surfaces all the metal is liquid at any given moment, whilst outside all is solid. It must be remembered, however, that at the same time that a metal solidifies it also contracts, which is the cause of piping in the parts of moulds where solidification was the last to take place. In a mould of simple outline—as, for instance, a solid cylinder—the pipe will be at one position only, that is, along the axis and throughout the length. Its exact form and position varies, of course, with the cooling conditions

For a second mould it is assumed that it is cast up with an alloy of which the temperatures at the beginning and end of the solidification are distinct, *id est*, the *solidus-liquidus* curves are more or less distinct in the vertical. As in the previous case, solidification takes place over the mould wall area, but on reference to the equilibrium diagram it is shown that the primary crystals should be surrounded by mother liquor of which the temperature at the beginning of the solidification is less than the temperature at the beginning of the primary alloy—that is, at the temperature of the commencement of the solidification of the metallic portions situated more towards the centre of the mould. This, it should be understood, presupposes that the diffusion of the elements is not instantaneous. As a result it can happen that independently of the crystals formed at the mould walls the germs of crystallisation, which soon commence to take definite form, can appear towards the centre of the liquid mass. Then, as the cooling proceeds, all the crystals develop, and in the course of time the interior of the mould resembles a solid sponge, the pores of which contain the mother liquor. The pores more or less connect up with one another in the earlier stages but later become isolated, and everywhere where an isolated liquid particle which has recently arrived at the temperature at the end of the solidification, the solidification contraction creates a void: this is what we have translated a micro-pipe, or, better still, as intercrystalline cavity. So far as cast iron is concerned, it should not be so liable to "micro-piping" because of the swelling of the graphite, but the trouble is often met with in automobile foundry practice when cylinders under water test are found to weep.

It is noted by the authors of the memoir cited that the tendency to make castings without feed-

XUM

ing heads, or with very small ones, is gaining ground, and they utter a warning that special precautions should be taken in order that the solidification contraction, small though it happens to be in the case of cast iron, should not bring out micro-piping, which may in reality be the large pipe disseminated throughout the whole mass. Mr. O. Smalley threw some light on this fascinating subject when he drew attention to the utilisation of definite composition so as to employ irons with as small a freezing range as possible with the object of producing internally sound castings.

Association of German Iron Foundries (Foundry Union).

Programme of Annual Meeting.

The 55th general meeting of the Association of German Iron Foundries, in conjunction with the fourth Foundry Exhibition of that body, will be held at Düsseldorf from August 26 to 29. The exhibition, held in Brüderstrasse, will be opened on Sunday, August 23, and continue until September 11.

Wednesday, August 26, will be devoted to various business and committee meetings of the Association, and in the evening there will be a reception at the Municipal Theatre.

On Thursday, August 27, the morning meeting will be held at 10.30 in the Wilhelm-Marx-Haus, Hindenburgwall, and reports will be delivered on "The Present Situation of the Iron Foundries" (Dr. Geilenkirchen, Düsseldorf), "The Present Situation in the Pig-iron Market" (Herr Steinmetz, Essen), "The Present Situation in the Coal Market" (name not yet announced), and "The Present Situation of Scrap." At the afternoon meeting at 3 o'clock in the Rittersaal of the Municipal Concert Hall, Schadowstrasse, Papers will be read on "Recent Efforts to Improve the Quality of Grey Cast Iron" (Dr. Piwowarsky, Aix-la-Chapelle), "Researches Relating to High-grade Cast Iron (Dr. Kühnel, Berlin), and "Observations on American Foundry Practice and its Application to German Conditions" (Dr. Werner, Düsseldorf).

On Friday, August 28, Dr. Werner, the President, will deliver his report on the year's work of the Association, and the rest of the sitting will be devoted to financial and other business. An excursion down the Rhine will be made on Sunday, August 29.

British Perlit Iron.

A British company has been formed, which is called the British Perlit Iron Company, Limited, the first meeting of which was held at the registered offices of the company, 15, Victoria Street, London, S.W.1, on July 20.

The company have purchased the British and Colonial Patent Rights of Heinrich Lanz, of Mannheim, Germany, for the manufacture of high quality grey cast iron, which passes under the trade name of "Perlit" iron.

The directors of the company are Mr. Summers Hunter, Jun., of the North-Eastern Marine Engineering Company, Limited, which company have taken a licence to manufacture Perlit iron; the Hon. L. H. Cripps, a director of Messrs. Alfred Holt & Company, of Liverpool, which company have also purchased a licence; Mr. Hans Meyer, of Messrs. Heinrich Lanz, of Mannheim, Germany, and Mr. John A. Smeeton, who has been appointed managing director.

The company have taken over from Mr. John A. Smeeton the rights he held to negotiate licences on behalf of Messrs. Heinrich Lanz, and are now in a position to dispose of licences to the British and Colonial foundry industry.

Mr. H. J. Young, F.I.C., the well-known metallurgist, has been retained as consulting metallurgist by the company, with the kind permission of the North-Eastern Marine Engineering Company, Limited, and his services will be at the disposal of all prospective licensees to advise them on all matters relating to the production of "Perlit" iron.

Foundry Query.

Power for Shot Blast (issue of July 2).

The question of power necessary for any plant depends, of course, on the type of chamber or machine in use, the number and diameter of nozzles, the pressure used and also whether sand or shot is the abrasive.

To enable "A. B. C." to form an idea as to what amount of power it is possible to work to, it can be stated that with the $\frac{3}{8}$ in. nozzle and with a pressure of about 15 to 17 lbs. per sq. in., no more than 20 h.p. would be required to drive a compressor and exhauster for an ordinary rotary barrel type machine. This would also apply to a small size chamber.

I shall be pleased to give "A. B. C." the fullest information should he care to address me, c/o The Editor, THE FOUNDRY TRADE JOURNAL.

"EFFICIENCY."

Industrial Training of Foundry Workers.

On July 22, at the Board of Education, an informal conference was held on the subject of the recruitment, industrial and technical training of workers in metallurgical industries, with special reference to foundry work. Various employers' associations, trade unions, technical societies, educational authorities and the representatives of the Board took part.

Amongst those present were Professor Desch, F.R.S., Dean of the Faculty of Metallurgy, Sheffield University, Mr. John Cameron, president of the Institute of British Foundrymen, Mr. J. G. Pearce, Director of the British Cast Iron Research Association, Mr. Tom Makemson, of the Metropolitan Vickers Company, and Mr. W. N. Davies, of the Board of Education, who presided.

Catalogues Received.

Plastic Wood, etc.—"The Nobel Exhibit" is the title of a handy publication issued by Nobel Industries, Limited, concerning their exhibit at the British Empire Exhibition. It contains much useful information to the trader or possible buyer of Nobel products who has not the opportunity of visiting Wembley Park. Outside the exhibit in the Palace of Industry Nobel products are also to be seen in the rifle ranges, in the coal mine and in the South African Pavilion, where African Explosives and Industries have a display of their products.

Copies of Nobel's exhibition book are available to our readers who would do well to send for it, if only to get acquainted with the wide ramifications of this important concern.

Railways.—Messrs. Herbert Morris, Limited, of Loughborough, have apparently endeavoured to make their latest publication as wide as possible in its appeal, and consequently only one page is devoted to foundry needs. We are aware, however, that other catalogues are issued from this firm, which devote much more space to the needs of this industry.

Distance Thermometers.—Pamphlet C6, issued by Messrs. Negretti & Zambra of 38, Holborn Viaduct, describes and illustrates thermometers designed for indicating and recording temperatures up to 500 deg. C. The principal employed in these instruments is the expansion of mercury in steel. When the mercury expands it gives movement to a Bourbon Tube which in turn actuates a pointer mounted on a dial, or recording instrument, thus eliminating gears, hairsprings and levers, and so avoids friction and back lash. The pamphlet consists of 24 well illustrated art pages.

Tools for Cutting Steel.—Two catalogues have been received from Henry Pels, of 40, Great Marlborough Street, London, W.1. They describe and illustrate plate splitting, punching, shearing and cropping machines, and joist shears for hand power.

Rimamurány Ironworks.—This concern has now joined the Austro-Czecho-Slovak iron and steel cartel without any definition of its allotment of tonnage.

Manufacture of Steel Castings in India.*

The progress of the steel industry in India is receiving so much attention at the present time that it will no doubt be of considerable interest to many to know that during the past two years a well-equipped modern steelworks has been established in Calcutta. Messrs. Sir Sarupchand Hukumchand & Company, the well-known Indian merchants, of 30, Clive Street, Calcutta, are the proprietors of this new steelworks, which are known as the Hukumchand Electric Steel Works. The factory is situated at Ballygunge, within a short distance of Ballygunge Station, Eastern Bengal Railway.

FIG. 1.—A GENERAL VIEW OF THE SHOPS.

The urgent need for a well-equipped modern steel foundry capable of turning out sound steel castings of all kinds at a reasonable price must have been realised by all Indian engineers during the past few years. The disadvantages of being entirely dependent on imported castings are obvious. Apart from the question of cost, the inconvenience and loss of output due to the failure of a steel casting in an engineering works are often most serious. If spares for replacement are not carried it may not be possible to replace a broken steel casting for many months, during which time the loss of output through machinery lying idle may be very heavy. The great Indian railways require very large quantities of steel castings every year for their rolling-stock, as also do the firms engaged in carriage and wagon building. It has hitherto been necessary for all the railways to keep considerable capital lying idle in the form of stock of spares to replace breakages. This would only be necessary to a limited extent if castings could be manufactured at short notice in India.

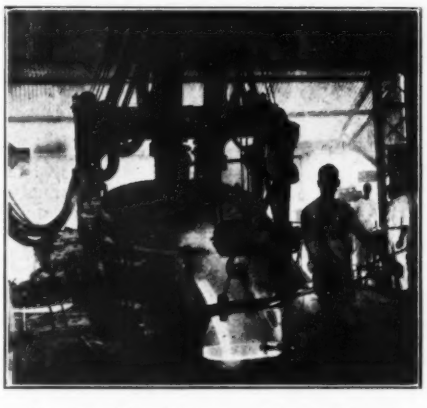


FIG. 2.—THE ELECTRIC STEEL FURNACE BEING TAPPED.

* Part of the information given in this article is obtained from "The Indian Railway Gazette."

The Works.

The Hukumchand Electric Steel Works have been established with a view to meeting this demand for steel castings, and the following brief description of the works will be of interest to engineers generally and to British foundrymen in particular.

Description of Works.

The works consist of a steel building of two 40-ft. bays, each 300 ft. long, with a 20-ft. verandah along the full length of either side. The buildings are so arranged on the site that extension to three or four times their present size would be a simple matter which could be carried out without interfering in any way with work in progress.

FIG. 3.—SAMPLES OF CASTINGS MADE.

Each bay is served by a 5-ton Babcock & Wilcox 3-motor type overhead electric crane.

The Iron Foundry.

The iron foundry having a capacity of some 50 tons per week has been equipped by the Constructional Engineering Company, Limited, of Titan Works, Birmingham. The main equipment consists of two Titan cupolas 21 ft. high by 3 ft. diameter, each with its separate high-pressure fan

and blast piping, while a single charging platform serves the two cupolas. The same makers have also supplied the 4 ft. and 4 ft. 6 in. sand mills, the two core-drying ovens (solid-fuel type) and the minor foundry requisites.

Steel-Melting Department.

The steel-melting department is arranged on the most modern lines, and is equipped with two 30-cwt. capacity "Stobie" electric steel-melting furnaces. The furnaces, although nominally of 30-cwt. capacity, have latterly been melting 40- to 45-cwt. charges regularly. Each furnace is capable of yielding five heats per day of 24 hours. Electric current for operating the furnaces is supplied by the Calcutta Electric Supply Corporation from their 6,000-volt 3-phase H.T. supply. The current is transformed down to the low voltage required for electric furnace working by means of Westinghouse transformers. Each furnace is equipped with a battery of three single-phase transformers, and there are three 6-in. diameter graphite electrodes per furnace, one in each phase. The total transformer capacity behind each furnace is 650 k.v.a. A separate motor operates each electrode, which is in turn hand-operated from a switch and instrument board placed at a convenient distance from the furnace. The transfer house is situated between the two furnaces, and when either furnace is in operation the transformer chamber is completely closed, all the operations being controlled from outside. The furnaces are of the tilting type, the tilting shaft and spur wheel gear being motor driven. The furnace lining consists of a backing of ordinary firebrick upon which is built a complete lining of magnesite bricks. The roof is of the best quality silica brick. The bottom consists of dead burnt dolomite, which is coarse ground and mixed with tar. It is then rammed in the furnace with hot rammers, and finally burnt hard with the electric arc. The dolomite is obtained locally in the raw state and calcined at the works in a special kiln. The main furnace switches are of the well-known "Reyrolle" manufacture. The manufacture of steel in the furnaces is under very exact scientific control. From the time the charge is melted until it is ready for tapping a series of spoon samples are periodically withdrawn, and these are carefully analysed in the works' laboratory until the required degree of purity has been obtained.

The required quantities of ferro-manganese, ferro-silicon, anthracite, etc., for a given composition of steel are then added, and the charge is "tapped" by tilting the furnace forward, so that the molten metal runs into a bottom-pouring ladle placed in position to receive it.

The whole of these ladles have been made by the Constructional Engineering Company, Limited, of Birmingham, the principal sizes being a 4-ton, three 35-cwt., and one 30-cwt. crane type, geared for tilting, and provided with patent bottom-pouring attachment.

Immediately the whole of the charge has been transferred to the ladle it is conveyed by means of the crane to the rows of moulds arranged on the foundry floor and poured into them by means of the bottom-pouring arrangement with which the ladles are equipped. The average composition of the steel used for general castings is as follows:—Carbon, 0.30 to 0.35 per cent.; manganese, 0.50 to 0.70 per cent.; silicon, 0.30 to 0.40 per cent.; phosphorus, not exceeding 0.03 per cent.; sulphur, not exceeding 0.035 per cent.

The results of some physical tests taken by the Metallurgical Inspector to the Government of India on a sample casting were as follows:—

	As cast.	After annealing.
Yield point.. ..	30.0 tons per sq. in.	22.0 tons.
Breaking load ..	37.7 ,, ,,	37.8 ,,
Elongation in 2 ins.	20.0 %	25.0 %
	Hardness test.	
Brinell number ..	160	160
	Bend test.	
Angle of bend before breaking.. ..	35°	68°

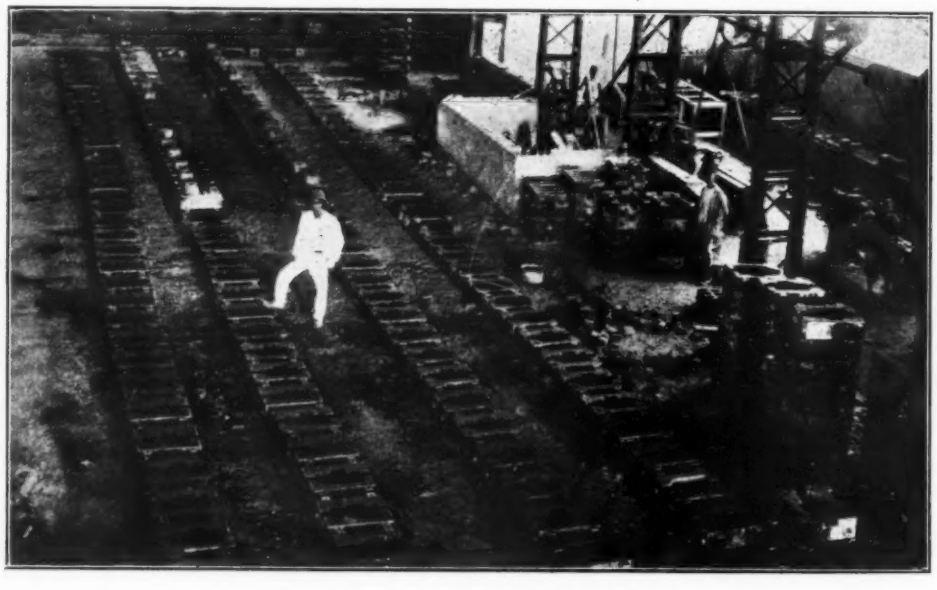


FIG. 4.—AXLE BOX MOULDS.

The casting in the annealed condition passes British Standard Specification.

The Metallurgical Inspector in the concluding portion of his report says:—

"The results indicate that so far as the quality of the steel (as shown by the composition and the tensile properties) is concerned, the castings made by the Company might be expected to comply with Grade 'A' of the British Engineering Standard Specification No. 30, and with Lloyds' Specification, *even as cast*, and if the castings were properly annealed they ought to pass these specifications with reasonable certainty."

British Standard Specifications are guaranteed, and, where required, test pieces and cast analyses are provided.

Advantages of Electric Melting.

The steel produced is of the highest quality, and this is largely due to the advantages of electric melting. These advantages may be briefly described as follows:—

1. The charge is not brought in contact with the products of combustion of carbonaceous fuel such as coal or coke. There is therefore no danger of such objectionable impurities as sulphur and phosphorus being imported to the metal from the fuel.

2. The melting of the charge is under absolute control, and any desired condition can be readily obtained in the furnace.

3. The casting temperature can be controlled within any desired limits.

4. The steel produced is purer, freer from dissolved gases, enclosed slag, etc., than is possible with any other process.

5. Steel of any desired chemical composition can be produced with comparative ease and with great accuracy.

Owing to the ideal conditions under which the refining of the metal is carried out, castings made from electric steel are singularly free from blow holes, contraction cavities, and such defects.

Moulding and Fettling Departments.

The moulding department is equipped with modern moulding machines, both hand and pneumatic, drying stoves, core ovens, sand mills, etc., and all the usual accessories of a modern foundry. Much patient research has been carried out in this department in order to determine the most suitable moulding-sand mixtures and refractory materials.

It was at first feared that a suitable moulding sand for steel moulding would not be obtainable in India, and had this proved to be true, it would have been a very serious handicap. Happily a highly refractory natural sand has been discovered, and the results obtained from its use have been most satisfactory.

The fettling and cleaning rooms are equipped with a large battery of cold sawing machines for removing risers and runners. Pneumatic hammers and chippers are being installed, and also a 600-ampere capacity arc welding outfit. Oxy-acetylene gas is used for cutting small risers and runners.

Annealing.

Particular attention is paid to the important operation of annealing, and this is carried out under pyrometric control. Annealing temperatures are regulated within very narrow limits.

The operation is a lengthy one, and from start to finish occupies about 36 hours. The furnace, which has a capacity of anything up to 20 tons, is heated up slowly until a temperature between 850 deg. and 950 deg. C., according to the class of steel being annealed, is reached. This temperature is maintained for 3 to 4 hours, and the furnace is then allowed to cool very slowly, remaining closed and sealed throughout the whole operation.

No castings are permitted to go forward for cleaning until they have been thoroughly and carefully annealed. The effects of this careful annealing are seen in the ease with which the castings can be machined and the extremely ductile character of the metal.

Castings Produced.

A very wide range of castings are undertaken, varying in weight and size from a few pounds up to two tons. These include all types of castings for railway rolling stock, such as axle-boxes, buffers, bogie centres, horn blocks, motion plates, frame stretchers, wheel centres, etc., etc. A large variety of castings for general engineering purposes are also produced, such as spur wheels, bevel pinions, pistons, anvils, etc.

Axle Boxes.

During the past year the works have been specialising in the manufacture of cast-steel axle-boxes on a mass-production basis, with the result that they can now guarantee delivery of 1,500 boxes of all types per month. It is hoped shortly to increase this output to 2,000 boxes monthly. The deliveries of axle-boxes to one important railway alone during the past three months averaged 1,200 boxes monthly.

The works supply axle-boxes in the form of rough castings only, or, if required, can supply them fully machined and fitted with face plates, studs and hats, dust and shield cover plates, etc. An exhaustive series of tests have been carried out to determine the strongest composition of steel for axle-boxes, and the castings now produced are capable of being tested up to ten times the limits of the standard specification without breakage. It may safely be asserted that the Company's steel axle-boxes are practically unbreakable in service.

Bogie Underframe Castings.

Castings for metre and broad-gauge passenger bogie underframes also form a large portion of the works' output. The works have turned out over 200 complete sets of these underframe castings within the past year.

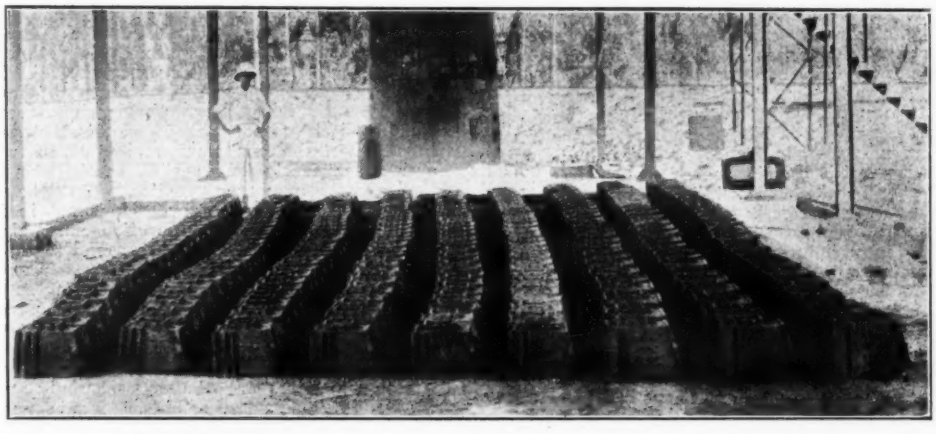


FIG. 5.—THIS ILLUSTRATION SHOWS A BATCH OF STEEL AXLE-BOXES AWAITING INSPECTION. THESE ARE PART OF AN ORDER FOR 20,000 BOXES ORDERED BY THE O. & R. RAILWAY.

Miscellaneous.

Steel in ingot form or in blocks can be supplied of any desired composition for the manufacture of dies for drop forging and stamping work. Considerable quantities of this steel have been supplied to various engineering firms and railway workshops with highly satisfactory results.

The average output from the works during the past few months has been approximately 100 tons of finished castings per month. The works are capable of producing over 300 tons per month.

The superior technical staff of the works consists of three Europeans, all of whom are home-trained and of wide experience. The junior posts are filled by Indians trained in the Company's own works. The works' chemist is also an Indian. The Company offer every facility for training apprentices, and opportunities are provided for those who make progress to fill posts as supervisors, etc.

Wills.

FIRTH, E. L., of J. & J. W. Longbottom, Limited, Bridge Foundry, Holmfirth ... £7,775

MANTLE, R., of Holly Hall, Dudley, lately manager of Lord Dudley's Castle Mill Iron Works £2,897

BULLIVANT, F. A., of Lincoln House, Basil Street, Chelsea, S.W., and of Bullivant & Company, Limited, wire rope manufacturers £56,358

The Selling of Castings.—XV.

BY VOYAGEUR.

It is essential that the manufacturer who indulges in the expense of advertising his castings should have some simple and ready means of estimating the success or otherwise of his endeavours to attract business by this means. His sales will fluctuate this way and that, and he will have no clue as to the meaning and cause of these fluctuations. An aggregate increased sale at the end of the year may, therefore, be put down to the credit of advertising that has, in reality, been consistently bad and damaging. Conversely, a bad year may be wrongly explained away as the fault of the advertising. In every foundry it will be found that sales respond to certain external stimuli apart altogether from internal activities, of which advertising is one branch. Thus, no amount of advertising, however excellent, could have removed the slump of 1920-1921, because there was not the money to spend, however much customers may have desired to spend it.

But although, in their aggregate, foundry sales are governed by trade and market conditions in general, they are still affected by and responsive to the advertising campaign, and it is these responses that need to be ascertained and controlled. Therefore some check upon the advertising is necessary, if selling is to be scientifically organised.

It must be said at once that no scheme, however elaborate, can measure with scientific accuracy the exact amount of business that advertising brings to the founder, nor decide its total value to him. The influence of an advertisement is psychological rather than material, and cannot, therefore, be weighed. All the manufacturer can hope for is an index, a pointer, showing, with a fair degree of trustworthiness, the way in which the wind is blowing. Such an index it is perfectly possible to obtain. The essentials of any checking scheme are as follows :—

(a) Some inducement for the reader of the advertisement to get into communication with the founder.

(b) Some means of tracing such a communication to its source in a certain advertisement in a particular journal.

There are five kinds of inducement that can be offered by advertisement. A sample casting may be offered to anyone sending a pattern, on condition that if it is found satisfactory it shall be charged for; but if not, it shall be returned carriage forward, and the invoice shall be withdrawn. A trial order on advantageous terms may be suggested. Some descriptive booklet, folder, leaflet, or catalogue, may be offered gratis. Information or advice on special problems may be offered. A special bargain offer may be put forward, to hold good only during certain dates.

It must be remembered that in addition to furnishing a check on the advertising, these inducements indicate to the founder the persons who are interested in the goods he sells. They enable him to send catalogues, travellers, circular letters, and so forth, until, perhaps, an order is at last secured. An advertisement containing some inducement that persuades the reader to write to the founder is half as good again as an advertisement that contains no such inducement.

The ways in which these replies can be tracked to their source are detailed below :—

(a) The reader is told to send his letter to a particular department, such as X2 or B3. These numbers are the key-numbers of certain trade papers and advertisements. Thus, X2 could be second advertisement of a definite series in THE FOUNDRY TRADE JOURNAL. B3 could be the third advertisement of a series in the *Automobile Engineer*. Each envelope bearing a departmental address of this kind could be picked out specially from the day's post, and sent to the Advertising Manager at once for recording purposes.

(b) The manufacturer's address is altered in each advertisement in some unimportant detail. Thus, one announcement may give it as William Brown & Company, Limited; another, as W. Brown & Company, Limited; a third as W. Brown & Company. Sometimes the number of the street is altered, when the address comprises more than one consecutive number. Envelopes are picked out in the same way.

(c) In the case of a special offer, this is made conditional on the mention by the applicant of the name of the journal carrying the advertisement.

(d) A coupon or request form is included in the advertisement. This is filled in and torn off by the reader, and the key-letter on the coupon enables the journal and the advertisement to be traced.

(e) The trade-name of the castings undergoes slight variations of spelling.

All these methods are useful in certain instances, but the simplest, best, least troublesome, and most effective, is (d). It is a proved fact that the presence of a coupon in an advertisement, even in an engineering advertisement, definitely increases the number of replies it draws. Probably this is because the labour of writing to the founder is thereby simplified. These coupons should never be so called. Their description in technical advertisements should be "request forms." It must not be imagined that they lower the dignity of an advertisement. This is a mere superstition. One foundry known to the writer receives, on an average, two thousand request forms per annum, from all grades of customers, including the very highest in the land. Obviously, therefore, dignity is not affected.

In the course of a year, it will be found that each advertisement has drawn a certain number of replies, and an examination of those that have drawn the greatest number of replies will show them to possess certain group qualities which those that have proved comparative failures do not possess. In this way the advertising manager will begin to discern the proper line of argument for his product. But in addition to comparing advertisements and the response they draw, it is necessary to compare different journals, and to see which, over a sufficiently long period, consistently draw the greatest number of replies. But the mere number of replies drawn by each is not in itself a sufficient guide. Consideration must also be paid to the quality of the replies, and to the cost of obtaining them. Thus, fifty requests from mere minor draughtsmen for literature, costing £2 each request to obtain, are not so valuable to the founder as ten requests from the works managers, costing 5s. each to obtain. Some sort of point-scoring system should, therefore, be devised, whereby points are allotted to each reply according to its quality, the higher numbers being awarded to orders and enquiries, the lower to requests from minor persons. The aggregate annual cost of advertising in a particular journal should then be reduced to shillings, and the figure thus obtained be divided by the total number of points scored by this journal in a year. This will give a final figure that may be taken as a basis for comparisons, embodying as it does the three essentials : number of replies, value of replies, and cost of replies. Journals that, when all have been classified in this way, figure consistently at the bottom of the list, are obviously not justifying the money spent on them, and can be eliminated without mercy. This system, which was first invented by the writer, has been practised by him and others for many years now, with admirable results.

To ensure that as many orders as possible are traced to their source, the founder should see that his Advertising Department has a record of all orders received. In this way it is possible for the Advertising Manager to note new customers, and to decide whether the order has been placed as a result of literature, etc., sent to them recently. Enquiries from new firms should also be listed in the same way.

IN THE CHANCERY DIVISION last week, Mr. Justice Eve confirmed a reduction of capital in the Chemical & Metallurgical Corporation, Limited. Mr. Uthwatt, for the company, said it was proposed to write off 19s. on each of the ordinary shares. The capital was £1,200,000, consisting of 200,000 cumulative preference shares and 1,000,000 ordinary shares, issued in consideration of certain patents. Counsel added that over 60 per cent. of the shareholders were represented at the meetings and approved the scheme. The existing £1 shares were to become 500,000 shares of 2s. each, taken at par value. The vendor or his nominees held 329,000 of the shares.

Reactions of the Basic Open-Hearth Furnace.*

By T. P. Colclough.

(*Continued from page* 81.)

In the normal working of heats, where desulphurisation is not required, the slag is usually on the "thin" side, and the furnaceman maintains throughout a certain excess of FeO in the slag. In consequence, the reaction proceeds from left to right, no return of manganese from slag to metal is to be observed, and the values obtained from Mn × FeO/MnO, while being variable, are consistently over 10×10^{-4}, the majority lying between 15 and 20×10^{-4}. Further, in the finishing stages of low-carbon heats, the furnace generates by "gas" oxidation considerable quantities of oxide of iron. If the carbon and phosphorus are both low, the content of FeO increases at a more rapid rate than the Mn-FeO reaction proceeds, and therefore samples taken at this stage invariably show high and rising values for the above ratio. K.3804, Table II, gives a good example of this.

In order to study this equilibrium more closely heat F.6124, Table IV, was followed. In this heat, some time after melting, the addition of ore was limited while fluorspar and limestone were worked in, so as to obtain a "thicker," *i.e.*, more basic, slag. The following points are to be noted:—(i) Slags 1 and 2 are "saturated" with phosphorus, hence reaction (6) cannot be acting. (ii) The manganese is practically constant, and equilibrium is apparently established.

This gives an excellent opportunity to calculate the equilibrium value, as given in Table VI.

TABLE VI.

Sample.	Mn.	MnO.	FeO.	$\frac{(Mn)\times(FeO)}{(MnO)}$.
	Per cent.	Per cent.	Per cent.	
1	0.24	9.86	4.24	10.3×10^{-4}
2	0.24	9.55	3.98	10.0
3	0.23	8.77	3.86	10.1
4	0.24	8.31	3.31	9.56
5	0.25	7.89	3.31	10.5
			Mean	10.1×10^{-4}

This may be taken as near the true value of the equilibrium constant K_3.

The return of manganese from slag to metal is observed only when the furnace is operated with a slag which carries an excess of lime. As pointed out above, the excess CaO is available to combine with P_2O_5 as fast as it is formed, the phosphorus Equation (2) has full opportunity to proceed, and both FeO and MnO are attacked. On thermo-chemical grounds, it may be assumed that the FeO is attacked first, and when this has been reduced *below* the amount necessary to give a value of $K_3 = 10 \times 10^{-4}$ the reversible Equation (3) operates, MnO is reduced, the manganese of the metal rises, and FeO is formed. This FeO is again reduced by phosphorus as quickly as it is generated, and the deficiency of FeO maintained, *i.e.*, $MnO + Fe \rightarrow Mn + FeO$. While this action operates, the values calculated for K_3 must be *below* the true value. This is illustrated in heat F.5816, Tables III and III(*a*), where the apparent values for K are 8.16, 8.23, 6.9, and 7.3×10^{-4}. On the other hand, if the furnace process is carried out at a sufficiently high temperature, there may be also a direct reduction of MnO by the endothermic attack of carbon or phosphorus, as shown in Equations (5) and (6). In this case the calculated values of K_3 will be higher than the true values because of the increase of the Mn/MnO factor.

Heat K.4822, Table VII, furnishes an excellent example of this action.

In this heat, spar and limestone were worked into the slag and the temperature raised, but no ore was added for two hours after melting. The following points are to be observed:—(i) The slag at melting is of "critical" composition. (ii) At Sample 1 the value of K_3 is 9.9×10^{-4}, *i.e.*, the equilibrium value. (iii) At Sample 2 the increase of CaO has made the oxidation of phosphorus possible, and by the decrease of FeO the Mn-FeO reaction is reversed: the manganese is rising, and the value of K_3 is 8.2×10^{-4}, *i.e.*, below the equilibrium value, as would be expected. (iv) From Samples 3-5, because of deficiency of FeO, the *direct* reduction of MnO has set in, and the values of K_3 are above the true value.

It follows, from the above considerations, that the distribution of manganese is not determined by one simple factor, but is the *net* result of a series of reactions, and that the basicity and FeO contents of the slag are vital factors. Further, calculations to determine the equilibrium constant (K) may be very misleading unless a full knowledge of the conditions prevailing is available.

If it be correct that the Mn . FeO reaction does not proceed to completion, but only to an equilibrium stage, two deductions of great practical importance to steelmakers can be drawn:—(*a*) The higher the manganese content of the metal as it approaches the tapping point and the less will be its content of dissolved FeO, *i.e.*, the less will be its degree of "wildness," and the better its rolling properties and soundness. This is fully borne out by practical experience. (*b*) No matter how much manganese is added in the ladle to "kill" the steel, it is impossible to remove *all* dissolved FeO, only a certain proportion can be removed. To obtain perfectly "sound" steel, it is necessary to add a further deoxidising agent to attack the residual oxide. Silicon owes its great power for this purpose to two factors—not only does it remove FeO by its own reducing power, but the SiO_2 thus formed combining with the MnO from the manganese reaction, removes the MnO from the reaction zone, and allows the FeO . Mn reaction to proceed still further towards completion.

Sulphur.

There are three possible courses open to the steelmaker for the removal of sulphur.

(*a*) *Addition of Ferro-manganese.*—If the steel-making process is carried out with a "thin" slag, there is a continuous fall of the manganese content, and no reduction of sulphur. In some cases, due to impurities in the oxide added, the sulphur actually rises—see K . 3804, Table II. To desulphurise, the addition of iron oxide is stopped and ferro-manganese, with lime, added. This added manganese combines with sulphur, the MnS formed rises to the slag, and is there oxidised to MnO and SO_2 which escapes to the chimney.

$$Mn + FeS \rightarrow MnS + Fe$$
$$2MnS + 3O_2 \rightarrow 2MnO + 2SO_2.$$

(*b*) *The addition of "Burnt" Lime together with a high temperature.*

(*c*) *The Addition of Fluorspar.*—These two methods may be considered together, as both involve the use of a highly-basic slag. When lime is added to the slag, it becomes thick and viscous, and to maintain fluidity either the temperature must be raised or some fluxing agent added, or both. The function of the spar is primarily to act as a fluxing agent, so that the slag may carry a high CaO content. In addition, there is evidence that, when fluorspar is present, the phosphate formed in the slag may have a composition CaF_2, $3\,CaO\,.\,P_2O_5$, *i.e.*, a fluor-apatite, instead of $4CaO\,.\,P_2O_5$.

Thus fluorspar acts in a double capacity. By its fluxing power it enables more lime to be carried at a given temperature, and, in addition, it reduces the amount of lime required to combine with the phosphoric oxide present. Both actions tend to give to the slag a higher capacity for carrying phosphorus. As shown above, whenever the slag contains an excess of CaO over that required for the critical composition, the oxidation of phosphorus proceeds very rapidly, the FeO content of the slag falls, the manganese equilibrium is disturbed, and the reduction of MnO causes an increase of manganese in the metal.

* A Paper read before a joint meeting of the Faraday Society and the Iron and Steel Institute.

Therefore, the real effect of a spar and/or high lime slag is equivalent to the addition of manganese to the metal, as in method (*a*), and the reduction of sulphur proceeds in the same way. The examples of this, given in Tables III and VII, and Fig. 2, giving six examples of this action, show the remarkable parallelism of this return of the manganese from slag to metal with the removal of sulphur.

low, there can be no reduction of the MnO, and therefore no increase of manganese in the metal. Further, immediately iron oxide is fed into the furnace, the manganese in the metal falls and the desulphurisation practically ceases (see Fig. 1). It seems probable that MnS reacts with FeO in the mass of metal as by equation:—(*a*) MnS + FeO→FeS+MnO, and the FeS formed remains in solution in the steel. If the conditions

TABLE VII.

Heat – K . 4822.	7.20	7.50	8.20	8.50	9.15	9.50	10.30	11.30
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Pe rcent.
Carbon	0.63	0.57	0.51	0.49	0.49	0.45	—	—
Sulphur	0.037	0.032	0.029	0.024	0.021	0.022	—	0.019
Phosphorus	0.366	0.334	0.300	0.193	0.172	0.096	0.055	0.020
Manganese	0.27	0.30	0.38	0.46	0.47	0.415	0.28	0.20
SiO_2	16.4	15.6	15.2	14.2	12.8	12.6	—	—
P_2O_5	15.53	15.93	15.83	15.53	15.16	15.04	—	—
FeO	3.2	2.06	1.93	1.64	1.54	2.96	—	—
Fe_2O_3	7.14	4.86	6.14	6.57	8.00	4.14	—	—
Al_2O_3	3.0	3.4	3.1	2.74	2.6	2.44	—	—
CaO	38.5	43.5	45.5	46.6	48.8	49.9	—	—
MgO	5.8	5.07	5.07	6.5	5.44	6.80	—	—
MnO	8.72	7.53	6.26	4.65	4.18	4.85	—	—
S	0.041	0.044	0.044	0.040	0.038	0.034	—	—
Molecular Analysis.								
SiO_2	0.273	0.260	0.253	0.237	0.213	0.210	—	—
P_2O_5	0.109	0.112	0.111	0.109	0.107	0.106	—	—
Base for $2RO.SiO_2, 4RO.P_2O_5$	0.984	0.969	0.952	0.911	0.854	0.844	—	—
Base Present:								
CaO	0.687	0.777	0.812	0.832	0.871	0.891	—	—
MgO	0.145	0.127	0.127	0.162	0.136	0.170	—	—
MnO	0.123	0.106	0.088	0.065	0.059	0.068	—	—
Total	0.955	1.010	1.027	1.060	1.066	1.129	—	—
Excess Base	−0.029	0.041	0·075	0.149	0.213	0.286	—	—
FeO	0.044	0.029	0.027	0.023	0.021	0.041	—	—
Fe_2O_3	0.045	0.030	0.038	0.041	0.050	0.026	—	—
$\frac{(Mn) \times (FeO)}{(MnO)}$	9.9	8.2	11.7	16.2	17.3	25.3×10^{-4}	—	—

In support of this, the following example from basic electric furnace practice may be studied. The five samples were taken at "slagging," half an hour after, and then at quarter-hour intervals. Silicon, spar, lime, and coal were added in the usual way, but no ferro-manganese was added till after Sample (5). Again the rise of manganese is accompanied by the elimination of sulphur.

are favourable, *i.e.*, there is an excess of FeO present, this MnO migrates to the slag and there is a fall of the manganese content of the metal, and the process of desulphurisation stops. This is shown in all the examples given.

This suggestion of a reaction between sulphur or MnS and FeO is supported by two commonly observed facts in practice. First, the segregated

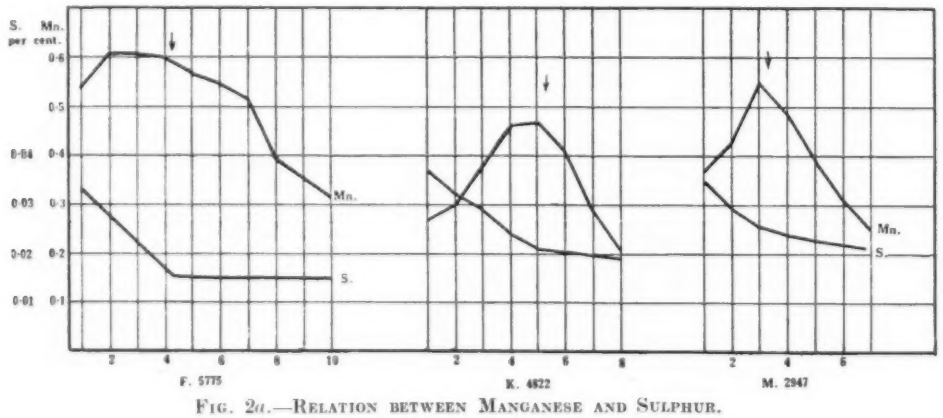


FIG. 2*a*.—RELATION BETWEEN MANGANESE AND SULPHUR.

These facts seem to point to the conclusion that the *active* agent in the elimination of sulphur in the basic furnace is *manganese*—this being intro-

	1.	2.	3.	4.	5.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Mn ..	0.07	0.08	0.10	0.12	0.14
MnO ..	10.5	6.5	3.7	1.5	0.5
FeO ..	38.2	2.9	2.2	2.2	2.2
S	0.040	0.040	0.038	0.028	0.020

duced either as a direct addition, or by the reduction of MnO from the slag.

The FeO content of the slag has a vital influence on this process. Unless the FeO of the slag is

areas, rich in sulphur, in steel ingots are never found to contain manganese and sulphur in the proportions required to form MnS—the sulphide is always a complex of (Fe . Mn)S. Second, if sulphur is added to semi-killed steel in the ladle, the resulting steel lies "dead" in the moulds, and the resulting ingots have all the characteristics of "killed" steel, showing an elimination of the FeO, which causes "wildness." Further, in basic electric-furnace practice, there is no elimination of sulphur during the oxidation period, when the metal is rich in FeO, and during refining no de-sulphurisation occurs until a non-oxidising slag is obtained, *i.e.*, until FeO is reduced to a minimum, and the small amount of MnO left from the first slag is being reduced to

manganese. From these facts, it seems clear that the FeO content of the slag is one of the controlling factors in the process of de-sulphurisation.

Constitution of Iron Oxide.

The exact nature of the oxide or oxides of iron in a basic slag is still a matter of speculation. Research work, on pure Fe_2O_3, indicates that at temperatures above 1,100 deg. C. the stable form has the formula Fe_3O_4, and this leads to the inference that at steelmaking temperatures FeO and Fe_2O_3 should be present in equi-molecular proportions. In a furnace, however, there is a conflict of opposing reactions. On the one hand, there are additions of FeO and Fe_2O_3 as ore, and the constant oxidising effect of the gases, tending to give Fe_2O_3. This is opposed by—(i) the instability of Fe_2O_3 at 1,600 deg. C.; (ii) the reduction of Fe_2O_3 by metallic Fe, as suggested by Whiteley; (iii) the impurities of the bath tending to reduce both oxides to metallic iron. Hence no simple relation, such as equi-molecular proportions, of the two oxides could be expected.

Examination of a large number of heats shows that the ratio FeO/Fe_2O_3 varies over a wide range, and its value depends upon the nature of the slag. Taking Table II—Heat K.3804—as typical of a heat with a "thin" slag and excess oxide, the following points are to be noted:—(*a*) The iron content of the slag is fairly constant until practically all carbon and phosphorus are oxidised, then, as their influence is removed, the oxidising effect of the gases shows its presence, and although no ore is added, the iron of the slag rises rapidly. (*b*) Throughout the heat, FeO is in excess of Fe_2O_3, and the ratio FeO/Fe_2O_3 varies from 1.6 to 2.5, with a mean value of 1.9 by weight, or 4.3 molecules of FeO to 1 of Fe_2O_3.

This value is borne out by Table VIII, which gives the average of 20 similar heats.

TABLE VIII.—*Ratio of FeO to Fe_2O_3 in Slag.*

Period.	By weight.	Molecular.
At melting ..	2.0/1.0	4.4/1.0
At tapping ..	2.3/1.0	5.1/1.0

On the other hand, heat F.5816, Table III, is typical of heats worked with very thick slags. This shows that, with high CaO content and limited oxide, the FeO content gradually falls, but after the first sample the Fe_2O_3 rises, even though the endothermic reduction of MnO is occurring.

Table IX shows that this action is typical, and not isolated.

In view of the recognised instability of Fe_2O_3 at the temperature prevailing, and especially so in the presence of the powerful reducing agents, carbon and phosphorus, this increase of Fe_2O_3 can only be explained on the hypothesis, previously advanced by the author, that ferric oxide is capable of forming a stable compound, with CaO, of the spinelloid type—$xCaO \cdot Fe_2O_3$—the existence and formation of which was demonstrated by Stead. This view is supported by the fact that crystals of this material have been identified by Scott and M'Arthur in solid slags.

In conclusion, the author would like to emphasise the important bearing that the composition of the slag has upon each of the reactions considered, and to point out how thoroughly justified is the common saying of melters—"Look after your slag, and the metal will look after itself."

TABLE IX.

Sample.	C.	P.	Mn.	CaO	MnO.	FeO.	Fe_2O_3.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
F. 5816—1	1.38	0.600	0.63	41.2	14.9	1.93	4.86
—2	1.36	0.464	0.94	48.5	6.4	0.56	2.66
—3	1.39	0.382	0.92	49.9	4.8	0.36	2.89
—4	1.37	0.342	0.92	52.0	4.4	0.35	3.26
F. 5775—1	1.14	0.346	0.54	50.0	6.10	3.86	4.43
—2	1.16	0.308	0.61	49.2	3.92	nil.	4.30
—3	1.13	0.233	0.61	50.3	3.92	,,	5.0
—4	1.10	0.205	0.60	50.8	3.89	,,	5.0
K. 4822—1	0.63	0.366	0.27	38.5	8.72	3.2	7.14
—2	0.57	0.334	0.30	43.5	7.53	2.06	4.86
—3	0.51	0.30	0.38	45.5	6.26	1.93	6.14
—4	0.49	0.193	0.46	46.6	4.65	1.64	6.57
—5	0.49	0.172	0.47	48.8	4.18	1.54	8.0

Almost the whole of the data used in the Paper has been gathered under ordinary working conditions on the plant of the Park Gate Iron & Steel Company, and the author is indebted to the Company for their kind permission to make use of it.

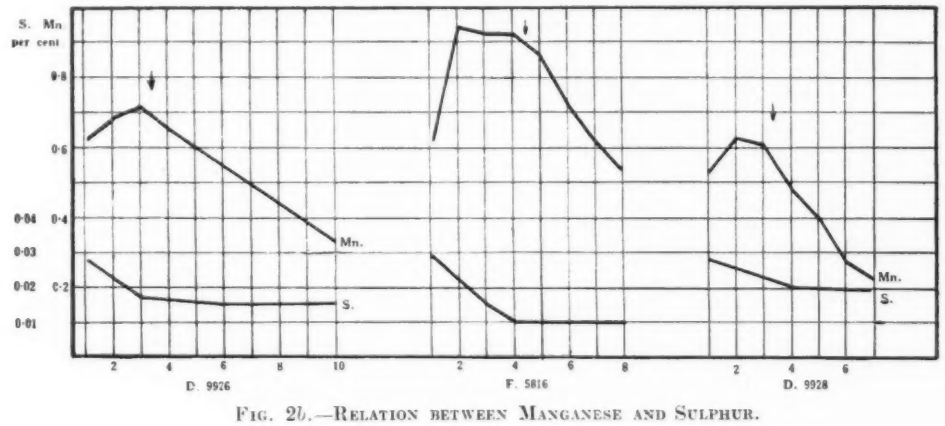


FIG. 2*b*.—RELATION BETWEEN MANGANESE AND SULPHUR.

APPENDIX.

Details of Charges.

Table II.—K.3804.

	Tons	Cwts.	Qrs.
Scrap	11	6	3
Hot metal	44	10	0
Gellivare ore—charge	6	10	0
Tap cinder—feed	3	18	0
Mill scale—feed	2	9	2
Limestone—charge	3	19	3
Limestone—feed	3	14	0

Time.	Limestone.	Tap cinder.	Scale.	Sample.
a.m.	Cwts.	Cwts.	Cwts.	
1.40	2 3	23.7	—	1
2.25	3.6	41.7	—	2
3.13	10.6	14.4	8.9	3
4.0	10.0	—	6.7	4
4.45	12.2	—	6.5	5
5.30	10.5	—	5.6	6
6.18	7.0	—	7.7	7
7.0	17.5	—	13.3	8
8.10				9
8.15	—	—	—	Tapped.

Table III.—F.5816.

	Tons.	Cwts.	Qrs.
Hot metal	20	0	0
Scrap	25	7	0
Gellivare ore—charge		nil.	
Gellivare ore—feed	1	12	0
Limestone—charge, and feed	5	17	0
Fluor spar	0	6	0

Time of Heat 15 h. 40 m.

Table VII.—K.4822.

	Tons	Cwts.	Qrs.
Hot metal	30	0	0
Cold pig-iron	6	0	0
Scrap	23	18	0
Gellivare ore—charge	3	9	0
Gellivare ore—feed	0	13	0
Limestone—charge	3	0	0
Limestone—feed	3	9	0
Burnt lime	1	13	0
Fluor spar	0	6	0

Table IV.—F.6124.

	Tons	Cwts.	Qrs.
Hot metal	24	0	0
Cold pig-iron	4	0	0
Scrap	22	10	0
Limestone	5	15	0
Burnt lime	1	2	0
Fluor spar	0	3	2
Gellivare ore	5	15	0

Time.	Sample.	Lime-stone.	Spar.	Ore.
p.m.		Lbs.	Lbs.	Lbs.
3.15	1	500	250	36
3.30	2	480	140	72
3.45	3	240	—	110
4.0	4	48	—	90
4.15	5			

In all cases the examples are taken from basic open-hearth furnaces, fixed type, of 50 or 60 tons capacity. The hot metal used is taken from a metal mixer—active—and this furnace is worked to give iron as near to the following percentage analysis as possible:—Carbon, 3.2; silicon, 0.5; sulphur, 0.035; manganese, 1.0; phosphorus, 1.6 per cent.

Contracts Open.

Johannesburg, August 22.—Tram track material, etc., for the Municipal Council of Johannesburg. The Department of Overseas Trade (Room 50).

London, S.E., August 5.—40-ton overhead electric travelling cranes, for the Director-General, India Store Department, Branch No. 14, Belvedere Road, Lambeth, S.E.1.

Rothwell, August 4.—6-in. and 8-in. cast-iron cement-lined water mains and "spun" water main pipes, also the necessary specials, for the U.D.C. Mr. J. Southwart, waterworks manager, Council Offices, Rothwell.

Batley, August 10.—About 400 tons of cast-iron pipes and special castings, 18-in. diameter, for the Waterworks Committee. G. H. Hill & Sons (Manchester), civil engineers, 40, Kennedy Street, Manchester. (Fee £1 1s., returnable.)

London, S.E., July 30-August 5, 7, 11.—Cast-iron pipes, spigot and socket, electric ceiling and table fans, and rolled copper bars, copper tubing and brass rods, for the Director-General, India Store Department, Branch No. 14, Belvedere Road, Lambeth, S.E.1.

Sandbach, August 3.—Provision and erection of pumping plant, consisting of heavy oil or suction gas engine with force pump to lift 18,000 gallons per hour, and crude water pump; also supply of about 600 yds. 8-in. and 370 yds. 5-in. main and specials, for the U.D.C. Mr. W. W. Wyatt, engineer, Whitchurch, Salop.

MR. A. J. ASH, of Packwood House, Lapworth, Warwickshire, the chairman of Ash & Lacy, Limited, Globe Galvanising Works, Great Bridge, Tipton, and Meriden Street, Birmingham, died in London on July 19. Mr. Ash, who was in his sixty-seventh year, had been intimately connected with the galvanised iron trade in South Staffordshire. He was chairman of Fellows, Morton & Clayton, Limited, and had many other business interests.

Methods and Aims of Grey Cast-Iron Refining.*

BY PROFESSOR DIEPSCHLAG.

The requirements which grey cast iron was expected to fulfil as regards its properties were not definite, but varied greatly according to the purpose for which the iron was intended. In grey cast-iron refining, therefore, the aims were not always identical and the measures for its improvement had to be taken from different standpoints. If it were desired to judge the quality of grey cast iron solely by its mechanical strength properties of the customary kind, it would necessarily be found that, compared with steel alloys, grey cast iron would always show lower strength values. This was due to the nature of grey cast iron, to the permeation of a metal alloy with a foreign body of very slight strength. It might be assumed that grey cast iron, being an inferior alloy in this respect, would not in future be able to compete at all with steel alloys. Nevertheless, grey cast iron possessed properties which would always maintain its value in future. The most important advantage consisted in the cheapness of this iron alloy as compared with steel alloys, and this circumstance must be borne in mind in all endeavours for improvement. All measures that involved any considerable increase in the cost of grey cast iron types of higher strength were ruled out from the start. For certain purposes, however, grey cast iron alloys afforded additional advantages; for example, it was not sensitive to atmospheric influences, the alloy was soft, and it was readily worked up by cutting tools. The refining of grey cast iron might proceed in two ways, namely, by suitable alloy and by heat treatment, or both methods might be employed simultaneously. With all measures of this kind a further important restrictive circumstance must not be forgotten, namely, that the alloy solidifies grey and yields a pourable melt. The number of possible alloy substances and the employment of large quantities were thereby narrowly limited. The research results available in this connection showed that the improvement of the grey cast iron was not enhanced by an increasing addition of an alloy material, but that with some alloys, as, for instance, silicon, no special influence on strength properties was to be observed, while with others, such as Mn and P, when increasing quantities were added the maximum improvement was soon attained. The strongest influence in altering the properties was shown by a decreasing content in carbon or graphite and an increasing content in sulphur. The amounts in the individual alloy substances were determined by suitable charges for the melt with the employment of such materials as contained the alloy materials in sufficient quantities. If such materials were not available, any excess of alloy elements had to be eliminated from the charge by special processes. This method was applied in the greatest variety of ways, *e.g.*, in diminishing the sulphur content, but it could also be employed on the same principles in reducing the graphite content. The method of improving grey cast iron by heat treatment consisted in allowing the metallic structure to solidify mainly pearlitically or quenched according to the rate of cooling. The desired object could be achieved more readily by influencing the solidifying and transformation processes by means of suitable alloy substances. In "Perlit" cast iron a high-grade alloy was already present in this respect. Grey cast iron was still generally sub-divided into groups according to the purpose for which it was intended. It would be more correct to designate and classify it according to its properties, as was already the case with "Perlit" cast iron.

THE DEGREE OF DOCTOR OF SCIENCE was conferred on Robert J. Anderson, consulting metallurgical engineer, Cleveland, Ohio, and Pittsburgh, Penna., by the Massachusetts Institute of Technology at the recent commencement on June 16, 1925.

* Extract of a Paper read before the German Foundrymen's Association.

Some Mechanical and Physical Properties of Cast Iron.—Part II.

By J. E. Hurst.

Impact Tests.

During recent years impact testing has occupied a prominent position in the regular mechanical testing procedure of engineering materials and is now being more systematically applied to cast iron, particularly by Continental workers. Hitherto impact tests have not been embodied in any of the standard specifications for cast iron. It is well known to all practical men that although cast iron is extremely brittle, yet various cast irons possess varying degrees of brittleness. Such varying degrees of brittleness are not disclosed by the ultimate strength values obtained from direct tensile or transverse breaking tests. The deflection of bars in the transverse test is often regarded as some index of the relative brittleness of cast iron, and this is probably more true in the case of cast iron than it would be in the case of more ductile materials like steel. The extent of this deflection is not sufficient as a guide in itself.

The crude form of impact test consisting of the breaking of a bar in a vice by means of a hammer discloses at once the relative brittleness of different specimens of cast iron even in the hands of the unskilled man. All foundrymen are familiar with the difference in effort required to break a hematite pig-iron as against a phosphoric foundry grade. Such crude breaking tests, whilst affording satisfactory indications of the property desired, have, however, the great defect of inability of quantitative expression.

Many forms of impact test have been devised with the object of enabling some form of quantitative expression being given to the result of such tests. Such tests can be broadly divided into two classes, viz., simple impact tests or single blow impact tests and repeated impact tests.

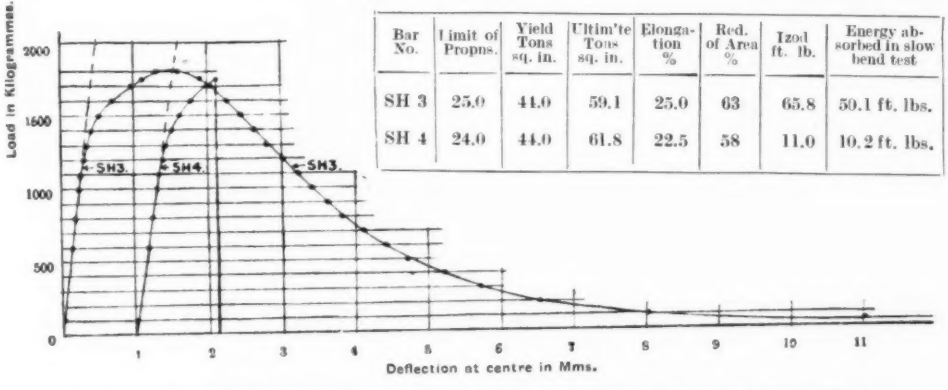
The earliest recorded systematic impact tests as applied to cast iron in this country were included in the exhaustive experiments of Hodgkinson and Fairbairn. These tests were of a varied nature, and included repeated impact tests. Tests were also included on beams of commercial sizes loaded and supported in various manners, and also with a view to determining the influence of increasing temperatures on the impact strength.

W. J. Keep in America[1] used a specially designed machine of the modern single blow pendulum hammer type. The blow from the falling hammer struck the test bar of square cross section supported at two ends in the centre. A rather involved method of expressing the results obtained from this test was adopted by Keep in which the numbers expressing the impact strength were obtained by reference to a table of standard values obtained on a good sample of Swedish iron. This method of expression does not readily lend itself to comparison with other methods.

[1] Keep. "Cast Iron," 1902.

A common form of impact test which has been used by F. J. Cook and is met with under several identifications is that in which a specimen is supported transversally and submitted to blows from a falling weight from a gradually increasing height until the specimen breaks. The final height of the weight from which the specimen is broken is taken as a measure of the resistance to impact. The indications of this type of test are somewhat complicated and are to be regarded probably as a sort of transition stage between single blow and repeated impact tests.

The most generally accepted single blow impact test in this country is the Izod test, which is of a similar nature to the Charpy and the Guillery tests in use on the Continent. In this test, as applied to notched specimens of ductile materials, the specimen is supported at one end in a specially designed vice and carried in a position at the lowest point of the arc of swing of a pendulum type of hammer. The reduction in the amplitude of the angle of swing of the pendulum after striking and breaking the specimen is proportional to the energy used in breaking the specimen.



Bar No.	Limit of Propns.	Yield Tons sq. in.	Ultim'te Tons sq. in.	Elongation %	Red. of Area %	Izod ft. lb.	Energy absorbed in slow bend test
SH 3	25.0	44.0	59.1	25.0	63	65.8	50.1 ft. lbs.
SH 4	24.0	44.0	61.8	22.5	58	11.0	10.2 ft. lbs.

FIG. 1.—STATIC TESTS AS APPLIED TO THE SAME STEEL IN THE LOW AND HIGH IMPACT-RESISTANCE CONDITION. (*Philpotts.*)

This is measured in foot pounds as the resistance to impact of the material. With the exception of very tough materials, the indications of the machines of the Izod and the Charpy type are identical. The variation encountered in tough materials is due to the fact that the specimens are not actually broken but bent, and the bending is not actually through the same included angle in each type of machine. The results of the Charpy and other Continental machines are usually expressed in kilogrammetres. The conversion of these units into foot pounds is obtained by the following equation:—1 Kilogrammetre = 7.233 foot pounds.

The impact test is essentially a measure of the total energy absorbed in breaking the bars under the conditions of the test. The total energy absorbed is not all utilised in stressing the material up to the elastic limit and bringing about the ultimate fracture of the specimen. Some of the energy is dissipated in other ways, as sound, in the local deformation of the specimen at the point at which the hammer strikes and also in the vice and in vibrations set up in the framework of the machine. The energy dissipated in these several manners cannot be separately calculated, and the absolute energy absorbed in breaking the specimen cannot be separately determined in this manner. For this reason the Izod impact value is not an absolute but only an empirical or comparative value. In actual practice it is necessary to specify arbitrary limits which are fixed as a result of numerous experiments with the particular materials concerned. It is of course only necessary to specify a minimum limit for most industrial purposes. It is important to appreciate this

point and that the bald statement of the impact value without reference to the remainder of the mechanical properties is of little value.

In many quarters it has been regarded that the indications of the impact test are due to the dynamic method of loading the specimen. An extensive research has been made* in which notched bars were statically loaded and bent or broken through the same included angle as in the Izod machine. The deflection of the notched bars transversally supported were plotted against the increasing loads and the exact amount of energy utilised in breaking or bending the specimens calculated. These energy values can be calculated with this static form of test with considerable accuracy and, as would be expected, were consistently lower than the direct values obtained from the dynamic Izod or Charpy tests. Exactly the same indications of brittleness were obtained from the static test, and the curves[2] given in Fig. 1 are typical of those obtained from the static test applied to the same steel in the low and high impact resistance condition respectively.

These experiments conclusively show that the indications of the impact test as applied at least to ductile materials like steel are not due to the dynamic nature of the test, but actually to the presence of the notch. In fact, the degree of sensitivity of the impact test under these conditions is intimately connected with the form of the notch.

The effect of the notch in ductile materials has been shown to concentrate the stress at that small portion of the material represented by a plane through the root of the notch, and under these conditions the specimen breaks without the deformation spreading through adjacent portions of the material. The energy absorbed is therefore almost wholly that required to break the material, and the varying amounts of energy required in the deformation of different materials which prevents a true comparison of the actual amounts used in breaking are eliminated.

Fremont Test.

In a brittle material like cast iron, which normally breaks without appreciable deformation, it would appear that the notch can be dispensed with and also that if the condition of dynamic loading is not essential, the ordinary form of transverse breaking of bars carried out with more precision in which the deflections of the bars plotted against the increasing loads up to final rupture would give the same indications. This is exactly what is done in the Frémont test, in which small specimens are bent until fracture under conditions of transverse loading, the deflection load curve being autographically recorded.

This point is illustrated by an examination of some of the comparative figures obtained by Keep in Table I. From this table it will be seen that within the limits of experimental error the indications of the impact test and the dead load (or ordinary transverse test) are identical.

The Frémont bending test machine has been fully described by Ronceray,[3] and the curves shown in Fig. 2 are typical of the load deflection diagrams obtained in this test. In comparing these diagrams Frémont uses the determination of the angle of slope of the curve. It is undoubtedly better to compare the areas enclosed by the curves. This area represents the work done in breaking the specimens, and the difference in energy absorbed in breaking the different specimens shown in this manner brings out very clearly the familiar difference in breaking properties so well known to the foundryman.

TABLE I.—*Influence of Elements on Impact Strength.* (*Keep*).

No.	% of Element. Si.	Dead load. Lbs.	Dead load. Deflection.	Impact. Lbs.	Impact. Deflection.	Remarks.
	%		Ins.		Ins.	
352	1½	365	0.23	373	0.29	From Table X. Page 38.
353	2	348	0.23	228	0.23	
354	2½	318	0.24	277	0.24	
355	3	348	0.30	401	0.32	
	Mn. %					Si. %
1	0	380	0.19	365	0.225	2.50 Table XL
2	0	398	0.195	323	0.225	2.51 Page 99.
3	1.08	380	0.195	271	0.182	2.51
2nd	Series					
1	0.50	353	0.27	373	0.29	1.53
2	1.66	357	0.28	381	0.26	1.51 Table
3	2.26	329	0.21	305	0.22	1.50 XLIII.
4	3.00	380	0.28	313	0.24	1.48 Page
5	3.83	331	0.26	330	0.25	1.47 101.
6	10.88	215	0.09	118	0.11	1.36

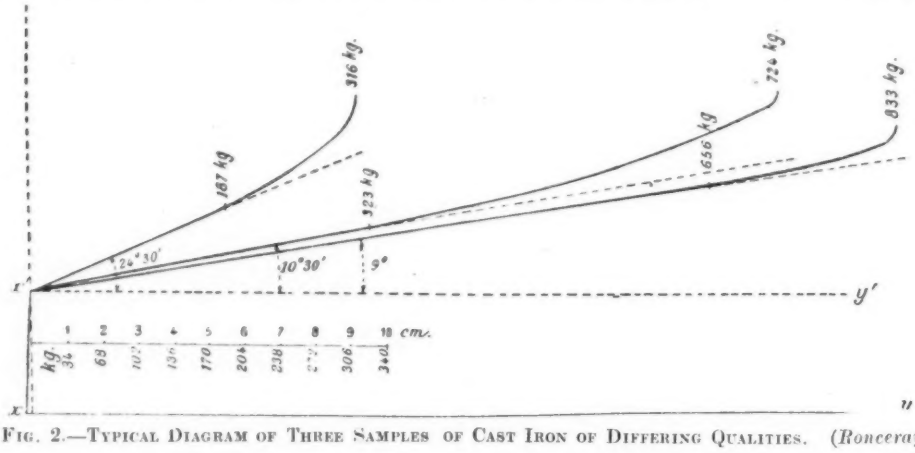


FIG. 2.—TYPICAL DIAGRAM OF THREE SAMPLES OF CAST IRON OF DIFFERING QUALITIES. (*Ronceray.*)

Influence of Elements on Impact Strength.

The results given in Table I extracted from Table II.

No.	Izod before heat treatment.	Brinell before heat treatment.	Izod after heat treatment.	Brinell after heat treatment.	Remarks.
60	6.00	212	8.00	207	
61	6.25	228	6.00	228	
62	6.50	228	—	196	
82	5.75	228	7.5	223	
85	6.00	228	10.0	207	Heat treatment maintained at a temp. of 550° C.—600° C. for a period of 150 hours.
69	4.50	255	6.0	228	
70	4.75	255	5.0	217	
71	4.50	255	6.0	228	
83	4.75	179	9.5	196	
84	4.75	241	6.5	170	
86	4.75	207	5.5	217	
87	4.50	228	6.0	170	

Keep's experiments show the impact resistance values with varying percentages of silicon and manganese. Without any definite information as to the condition of the carbon in these specimens it is difficult to draw any conclusions from these results as to the intrinsic influence of these elements. In so far as they go the results clearly show that the influence of manganese in percentages usually met with in commercial irons does not tend towards increased brittleness.

[1] Philpotts. Inst. of Auto. Engineers, 1918.
[2] J.Proc.I.B.F., 1921–22.

Stadeler[4] in discussing the researches of twist and his pupils states that the resistance to impact shows greater sensitiveness to the silicon, manganese and phosphorus present than other tests. The resistance to impact diminishes rapidly as the phosphorus rises until a percentage of 0.60 per cent. is reached, above which the decrease in resistance to impact is inconsiderable.

The effect of a prolonged low-temperature heat treatment on the Izod impact value of cast iron is illustrated by the results given in Table III. These results show a general increase in the impact value. The chemical composition and the tensile strength before and after heat treatment are given below:—Tot C, 3.06; CC, 0.59; Gr, 2.44; Si, 3.27; Mn, 0.49, S, 0.087, and P, 0.75 per cent. The tensile strength before heat treatment was 16.00 and after 13.88 tons per sq. in. This simultaneous drop in tensile strength after heat treatment confirms the results obtained by Rolfe, whose results are embodied in the diagram Fig. 3. The impact tests in this case were obtained on the Stanton Repeated Impact Testing machine, using ½ in. fall of tup and making 80 to 90 blows per minute. The increase in impact value at temperatures of 600 deg. C. with the simultaneous decrease in tensile value is clearly shown. The repeated impact test used in these experiments has not been extensively applied to cast iron.

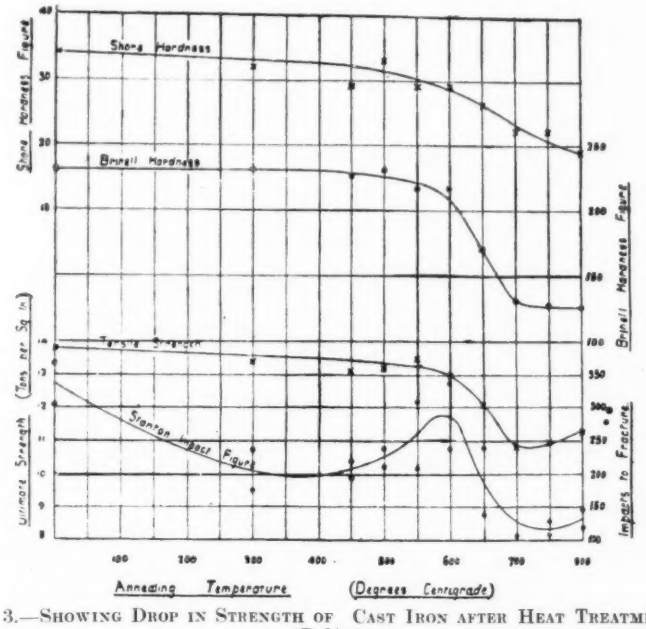


FIG. 3.—SHOWING DROP IN STRENGTH OF CAST IRON AFTER HEAT TREATMENT. (*Rolfe.*)

The Specific Gravity of Cast Iron.

The density of any substance, as is generally known, is its weight per unit volume, and is expressed by the relationship $\frac{M}{V}$ where M is the mass of the sample and V the volume. The density of any substance compared with that of water is known as the specific gravity. In metrical units where the specific gravity of water (at 15 deg. C.) is taken as unity, the specific gravity and the density of a substance at 15 deg. C. are numerically equal. The reciprocal of the density known as the specific volume is often referred to and used in technical calculations.

The specific gravity of cast iron is a common physical property which is very frequently neglected in investigation work. The standard values of the specific gravity of cast iron are to be found in most engineering pocket books, and are set out below:—

Specific Gravity of Cast Iron.

The least and greatest specific gravity ..	6.9—7.5
White iron	7.5
Grey iron	7.2
Mean value for ordinary calculations	7.217

Cast iron has the lowest mean specific gravity of ferrous materials used in industry, and for the purposes of comparison the figures for cast iron, wrought iron and steel are set out below:—

	Cast iron.	Wrought iron.	Steel
The least and greatest sp. gr.	6.9—7.5	7.47—7.808	7.729—7904
Mean value of sp. gr. ..	7.217	7.698	7.852

If we assume that the principal difference between cast iron and steel is the difference in carbon contents, we may conclude at once that the lower the carbon contents, the higher the specific gravity.

Relation between Specific Gravity and Chemical Composition.

The earliest systematic determinations of the relation between the specific gravity and the chemical composition of cast iron are to be found in the classical research of Prof. Turner on the influence of silicon on cast iron. The values obtained in this research show a general decrease in specific gravity of cast iron with increasing silicon and graphitic carbon contents.

A series of determinations were made by Hailstone in his investigations.[5] In this series the total composition of each member is practically identical, the only variation being in the proportions of combined and free carbon. The values are included in Table III.

These samples were all cast at a decreasing casting temperature from No. 1 downwards, and the change in proportions of combined and free carbon are entirely due to this cause. The gradual decrease in specific gravity will be noticed. This is partially due to the gradual increase in graphitic carbon contents, and it may partially be due to some other influence of the casting temperature. The results, however, do serve to show the steady decrease in specific gravity with increasing percentages of free carbon. This is as would be expected, for it is a general rule that within the limits of the percentages of constituents present in commercial alloys either in the form of solid solutions or conglomerates that the density varies with the composition in a linear or purely additive manner. The mean specific gravities of mixtures of iron having a specific gravity of 7.86 and graphite having a specific gravity of 2.55 would be expected to gradually decrease with increasing proportions of graphite.

The intrinsic influences of the other elements

[4] F. T. J., Aug., 1917.

[5] J.I.S.I. Carnegie Memoirs, 1916.

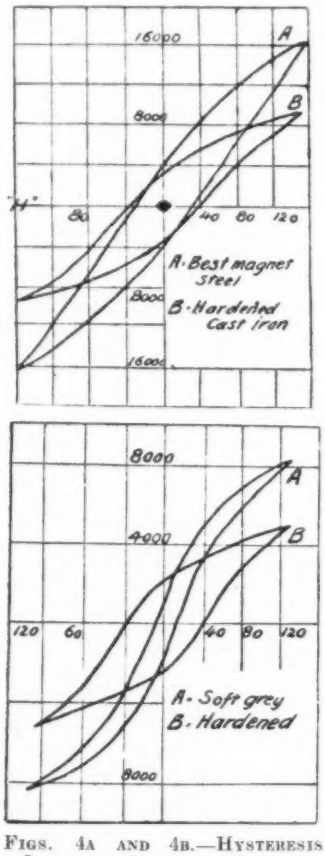
present in cast iron can be determined in a like manner if the condition in which these various elements exist is known and also the density of the component in which the element exists. The specific gravities of some of the constituents which exist in cast iron are tabulated below:—

Constituent.	Specific Gravity.	Authority.
Pure iron. Ferrite ..	7.85	Benediks.
Graphite	2.55	
Carbide of iron. Cementite Fe_3C.	7.66	Andrews.
Pearlite	7.74	Juptuer.
Iron sulphide Fe S. ..	5.02	Holman.
Manganese sulphide Mn. S.	3.99	McCance.

In his experiments with steels Benediks found that the addition of 1 per cent. of each of the following elements raised the specific volume, the reciprocal of the density by the following amounts:—

Element.	Increase in specific volume.
Manganese	0.00006
Phosphorus	0.00089
Silicon	0.00117
Aluminium	0.00200

With the exception of phosphorus it is probable that these elements would exert a similar quantitative influence in cast iron apart entirely from their influence on the condition of the carbon. In the presence of carbon the phosphorus no longer remains in solution in cast iron, but is thrown out as the binary eutectic which may affect its influence on the change in specific volume.



FIGS. 4A AND 4B.—HYSTERESIS LOOPS OF QUENCHED IRON AND MAGNET STEEL. (*Prof. Thompson.*)

In general, therefore, it may be taken that an increase in total carbon contents tends to lower the specific gravity of cast iron and within the percentages usually present in commercial cast iron and increase in the constituents manganese, silicon, sulphur and phosphorus act in a like manner. In all probability the most powerful element present in cast iron which has the effect of lowering the specific gravity is the graphite.

Magnetic Properties.

The technical and commercial importance of the magnetic properties of cast iron have been brought into prominence of recent years by the extended application of cast iron in the construction of electrical machinery. Very little information is available on the magnetic properties of cast iron. Researches on these properties of ferrous alloys have been largely confined to the low-carbon members—steels.

TABLE III.—*Specific Gravities of Various Cast Irons.*

Sample No.	1.	2.	3.	4.	5.	6.	7.	8.	9.
Total carbon ..	3.258	3.246	3.261	3.256	3.281	3.283	3.291	3.295	3.305
Com. carbon	0.428	0.406	0.399	0.365	0.366	0.357	0.340	0.308	0.293
Graphite	2.830	2.840	2.862	2.891	2.915	2.926	2.951	2.987	3.012
Si.	1.907	1.875	1.900	1.898	1.894	1.904	1.915	1.901	1.902
S.	0.114	0.097	0.092	0.096	0.096	0.094	0.094	0.093	0.093
P.	1.482	1.414	1.408	1.412	1.441	1.441	1.460	1.471	1.469
Mn.	0.420	0.270	0.265	0.268	0.268	0.267	0.265	0.266	0.264
Sp. gr.	7.281	7.262	7.240	7.225	7.201	7.158	7.123	7.085	7.012

The magnetic properties of materials present several features on which information is desired. These features are respectively (*a*) the magnetic permeability, (*b*) the coercive force, and (*c*) the hysteresis loss. Complete definitions of these properties may be obtained from standard text books on magnetism and electricity. Very briefly it may be stated in reference to (*a*) that in a magnetic field of a given strength the intensity of the magnetism induced in a body depends upon the nature of the material. The property of the material determining this intensity under any particular conditions of field strength is known as the magnetic permeability, and is defined by the relation

$B = \mu H$ where H is the field strength.
B ,, ,, magnetic induction.
μ ,, ,, permeability.

In all cases the removal of the magnetising force does not result in a total loss of the magnetism induced in the body, but a certain amount always remains. This is measured by the extent to which an opposing force is required to remove this residual magnetism, which force is known as the coercive force. The coercive force is thus a measure of the residual magnetism.

If a piece of steel has a magnetising force applied to it gradually increasing in magnitude up to a maximum positive value, then decreased gradually in the negative direction to a maximum negative value, it is found that the curves expressing the relationship between B and H with the positive and negative increment in magnitude of H do not coincide with the similar decrement in magnitude, and the result is an enclosed curve of the type shown in Fig. 4. The area of the enclosed portion of the curve is known as the hysteresis loss, and indicates the work done upon the iron by the magnetising forces applied. This work done is dissipated principally as heat and is a definite loss in the magnetisation of any piece of iron. It is usually expressed in watts per lbs. of metal or ergs per c.c. per cycle.

In materials required for permanent magnets the residual magnetism and coercive force is required to be as high as possible, whilst for armatures in electrical machinery a high magnetic permeability is required. The rapid reversal of the magnetic field in A.C. machinery is accompanied by the hysteresis loss which makes its appearance in the form of heat. A low hysteresis value is desirable in material for A.C. machinery to reduce this tendency towards overheating.

The use of chilled cast iron for permanent magnets in the place of special steels has been found possible. Ashworth and Pierce[6] have shown that white iron specially prepared leaves nothing to be desired in the way of permanent

[6] Annual Report, N.P.L., 1905.

magnets. These experiments were subsequently confirmed by Campbell[7] and the subject was fully investigated by Thompson,[8] who investigated the heat-treatment conditions necessary for the best permanent magnets in cast iron. He showed that in many ways cast-iron magnets prepared in the correct manner possessed distinct advantages over some steels.

The great disadvantage of cast iron for this purpose is the formation of minute hair cracks on hardening which break up the continuity of the material. Plates of graphite act in exactly the same manner and utterly ruin the magnetic permanence. In fact, magnetic tests have been suggested for the detection of hair cracks in hardened and tempered steel articles.

No data is available on the influence of manganese on sulphur and phosphorus, but it has been shown that the presence of silicon lowers the coercive force and reduces the hysteresis loop, destroying the qualities of permanence. The permeability of malleable cast iron is much higher and the hysteresis loss smaller than grey cast iron, due to the fact that the free carbon is distributed in small, rounded nodules, which do not interfere with the continuity of the material to as large an extent as the graphite plates in ordinary grey cast iron.

In connection with steel, it has been shown that the permeability and the saturation value decrease with increase in carbon content, whilst the coercive force and hysteresis loss increase as the carbon is increased.

We may broadly draw the following conclusion with respect to cast iron: (*a*) That the permeability is increased by a reduction in the total carbon and the graphitic carbon contents; (*b*) the smaller the graphite and the less it interferes with the continuity of the material the greater the permeability and the less the hysteresis loss; and (*c*) the coercive force and the hysteresis loss are increased with an increase in carbon content and decreased with an increase in silicon content.

Non-Magnetic Cast Iron.

A special variety of cast iron has been invented by Mr. S. E. Dawson, of Ferranti & Company, Limited.[9] The magnetic and electrical properties of this cast iron, which essentially contain a considerable quantity of nickel, are set out below:—

	Maximum permeability.	Specific resistance.
Non-magnetic cast iron ..	1.03	140.0 Micro-Ohms per Cm³.
Brass ..	1.00	7.5 ,, ,, ,,
Ordinary cast iron	333.00	95.0 ,, ,, ,,

This material has found extensive application in the construction of electrical machinery. It is admitted that the influence of the nickel is somewhat obscure, but it is considered to be due to its effect in lowering the pearlite change point to at least atmospheric temperature, and consequently retaining the austenite solid solution. Sufficient nickel (about 12 per cent.) is added for this purpose.

The Electrical Conductivity of Cast Iron.

The electrical conductivity of a material is usually spoken of in terms of its reciprocal of the resistivity. The specific resistivity is defined as the resistance between the faces of a cube of one centimetre length and one square centimetre cross-sectional area. The specific resistivity is usually expressed in micro-ohms per cubic centimetre.

The specific resistivity of pure iron determined by Dr. Yensen on an extremely pure sample of iron is 9.87 micro-ohms per c.c. at a temperature of 20 deg. C.

The increase in carbon contents in steel is well known to be accompanied by a steady increase in resistivity. The influence of various elements on the resistivity of iron have been thoroughly investigated, and an exhaustive summary of these investigations has been given by Norbury.[10] The following results have been extracted from this source, and show the amount of the increase in specific resistivity which accompanies the addition of 1 per cent. of the added element:—

Element.	Increase in resistivity.
Carbon	34.0 Micro-Ohms per Cc.
Silicon	13.5 ,, ,, ,,
Aluminium	12.0 ,, ,, ,,
Manganese	5.5 ,, ,, ,,
Chromium	5.4 ,, ,, ,,
Nickel	1.5 ,, ,, ,,
Phosphorus ..	11.0 ,, ,, ,,
Copper	4.0 ,, ,, ,,

The value given above for carbon refers to the carbon in the combined condition as cementite, and not in the free or graphitic condition. As in the case of the magnetic properties, the interruptions in the metallic continuity caused by the graphite plates in grey cast iron would be expected to have a very marked influence on the conductivity. For this reason the influence of the additional elements on the resistivity given above is entirely independent of their influence on the condition of the carbon. We may assume that the formation of graphite is accompanied by a considerable increase in resistivity, so that the influence of any of the above elements in cast iron will be increased or decreased by an amount corresponding to their influence in forming or preventing the formation of graphite.

The numerical value of the influence of graphite does not appear to have been investigated. We may anticipate that the size and distribution of this constituent would affect the results. This is evidenced in the values usually taken for calculation purposes of the specific resistivity of cast and malleable cast iron as follows:—

Material.	Specific resistivity at 0° C.
Soft cast iron	74.62 Micro-Ohms per Cc.
Hard cast iron	98.04 ,, ,, ,,
Soft malleable cast iron ..	23.00 ,, ,, ,,
Hard malleable cast iron ..	32.68 ,, ,, ,,

[7] Report, Executive Council, N. P. L., 1905.
[8] Sheff. Branch, B.F.A., 1915.
[9] F.T.J., May 29, 1924.
[10] J. I. S. I., No. 1, 1920.

British Engineering Standards Association.

Seventh Annual Meeting.

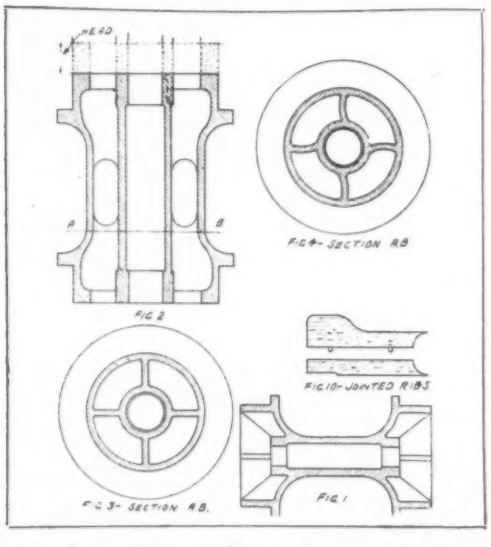
When the British Engineering Standards Association held its seventh annual meeting recently, the chairman, in his review of the year's work, was able to strike a more hopeful note than this time last year, both as to organisation as well as finance. The balance-sheet showed that the deficit carried forward from the previous year had been reduced from over £1,900 to £677. He regretted, however, that owing to there being at the present time no further funds for the purpose the valuable work of translating the British Standard Specifications into foreign languages and disseminating them abroad had had to cease. A new scheme was, however, to be put into operation in the autumn by which the Main Committee was hoping to obtain the support of professional engineers, individual firms and business men connected with all the great industries of the country, through the reorganisation of the Association's membership. The members, who will be admitted at a minimum annual subscription of two guineas, will have certain privileges, including direct representation on the Main Committee itself. The present contributors are in the meantime being consulted on the new scheme and invited to join without further fee, and to maintain their present contributions, thus enabling the B.E.S.A. to enlarge its scope, and, at the same time, make its work effective throughout the world.

The members of the Technical Committees who give their time and experience to this national work without fee or recompense, and who now number some 2,300, are in the future to be known as honorary members. All members will be entitled to certain privileges, including direct representation on the Main Committee, through a duly elected Advisory Council, as well as being able to apply to the organisation for advice on any matters of simplification or standardisation, as carried on in this country, and in the other large producing countries. It is moreover hoped, in view of the importance of the work the Association is carrying out for the industries of the country, that H.M. Government will eventually agree to support this national movement to a greater extent than is the case at present.

Piston Valves.

By Ben Shaw and James Edgar.

It may be thought that, in a series of articles dealing with valve chest, a description of the making of piston valves is out of place. In all foundries, however, where valves are made in a variety of designs, piston valves are considered in the same class as valve chests, although they are not really so, because the valve chest is actually part of the cylinder itself. The principle of the design of this type of valve is to obviate the pressure on cylinder faces. This is accomplished by making the valve circular. The back of the valve is then similar to the face and slides in contact with the valve chest, which has recesses corresponding to the cylinder ports and communicating with them. It is in the high-pressure cylinders of marine engines that this arrangement is more perfectly carried out and which is now very largely used. The piston valve may be described as a slide valve in which the valve face is curved to form a complete cylinder round whose whole circumference the ports extend. In some designs of cylinders the steam reaches the piston valves



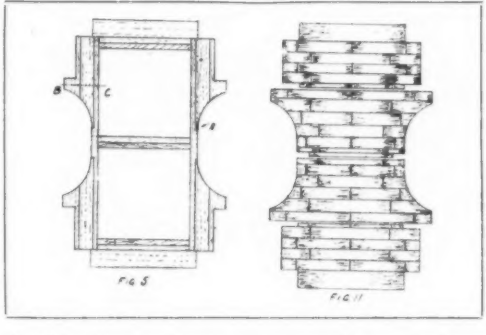
through two distinct inlets at the top and bottom, or the steam may have one inlet at the centre of the valve and be exhausted at top and bottom. Other piston valves are hollow and form a communication between the steam chambers above and below the valve, thus making one inlet suffice. There are, therefore, two types of piston valves, one known as the solid type, as shown in Fig. 1, for which either two steam inlets are required or the exhaust chamber connected to both top and bottom; or the piston valve may be hollow, as in Fig. 2, and used to connect top and bottom chambers either for steam inlet or exhaust, but usually the former. The designs of each type are very much alike, the main modifications made referring more particularly to the piston rings and the method of ribbing the hollow valves.

The making of the solid type of piston valve is simpler than the other type, but some difficulty may be experienced in consequence of the varying thickness of metal in this design.

Invariably the pattern is made solid and jointed longitudinally along the central plane. The mould is prepared in a vertical direction. Some moulders prefer to cast horizontally, in which position risers are advantageously used. Casting vertically gives facilities for using a feeding head, which ensures sounder metal. With either method, chills can be used advantageously to regulate the cooling of the metal.

The hollow type of valve is more general in marine work, and the making of these castings involves some interesting problems both in the pattern shop and foundry, although in foundries where there is a steady run of them methods become stereotyped. These castings are made in various sizes and the length and diameter of the main part, to a considerable extent, decides the method of moulding and of constructing the pattern. Piston valves of this type may be made from solid timber, and even medium-sized valves, because of the awkwardness of the design, are frequently made solid when a much more satisfactory pattern would result if they were either built segmentally or with grounds and staves.

In the hollow type of piston valve, such as is illustrated in Figs. 2, 3 and 4, the difference in the design, from a foundryman's point of view, is in connection with the internal ribs. These may be straight, as shown in Fig. 3, or curved, as shown in Fig. 4. In valve work, whenever possible, it is advisable to curve internal ribs, particularly if they connect bodies of metal of unequal thickness, as this lessens the possibility of defective castings through cooling strains, which may result in fracture, and very little more labour is involved in pattern work and moulding. Designers, as for all other work, do not always give contraction the consideration it ought to have when designing castings, and although no defect may be noticed when the casting is taken from the sand, or even after it is dressed and machined, there is often a weakness or concealed fracture which manifests



itself in time and may cause great inconvenience and expense.

It is customary, and advisable, to cast a head of metal on one end of these piston valves. With regard to the amount of head necessary, this is a matter for the joint consideration of the foreman in the pattern shop and foundry, and depends to some extent on the length of the casting. The question of head must necessarily be settled before a commencement is made with the construction of the pattern. In practice the amount of head varies from 3 to 9 in., but generally either 4 or 6 in. will suffice for average work. Some give a head to the valve rod barrel only and use risers on the outer barrel, but obviously, if there is need for the use of a head on the inner cylinder, it is just as necessary on the outer one: in fact, more necessary because a sound surface is required for the piston rings. It is not necessary to shape the head at all, as is done for some cylindrical castings, but merely to extend the section of metal at the end, as shown in Fig. 2, the amount decided upon. The ribs do not, as a rule, extend to the ends of these valves, and are not extended with the head. The pattern must be made sufficiently long to include the head required to be cast on. Although these castings are invariably poured vertically, the moulds are usually made horizontally and raised to the vertical position for casting. This method is more convenient and certainly less costly than making a mould vertically, as a two-part box will suffice and coring is simplified.

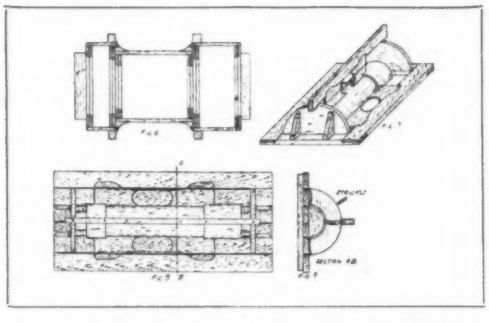
Working from Split Patterns.

A section of a pattern made in two halves and jointed horizontally is shown in Fig. 5. It is particularly desirable for work of this kind that the grounds for the barrel should be made in two thicknesses with the grain crossed. This method does not take much extra time or material, and it should always be adopted with lagged work for such patterns, unless for one-off jobs. It will be

observed from Fig. 5 that the pattern is built of a thin inner circle of staves on which outer staves are placed to make up the required diameter at the ends. It is not absolutely necessary, but it certainly makes a better job to check the first layer of staves, as at A, Fig. 5, because it obviates sharp edges. The first staves need not be more than 1 in. thick.

It is occasionally possible to get the full thickness, B, C, Fig. 5, out of two thicknesses of timber, and if this can be done by making the first lagging thicker, it is well to do so. On the other hand, there is often so much difference between the largest and smallest diameters that it is better to use four grounds, stepping the inner ones, as in Fig. 6, and lagging the different diameters.

The fillet pieces can be let in to obviate sharp corners, as with the previous method. This method makes quite a good pattern, and, though there is practically no saving in labour, there is considerable saving in timber. The preparation of lagging for such work is a comparatively simple operation, providing normal mechanical facilities are available. If a gauge is made for setting the fence of the surface planer, enabling the lagging to be edged to the radial taper, the pieces will not require to be touched at the bench. Occasionally a ring of segments is used to complete the largest diameter, and these are attached after the lagged work has been turned to a suitable diameter. As



these patterns are sometimes comparatively large and heavy, too great care cannot be exercised to make them secure when turning, and the lathe should revolve at a lower speed while the work is rough turned in order to reduce vibration. When the work has been tried the cutting speed may be increased with advantage for finishing. The cutting speed of the largest diameter should not exceed 2,000 ft. per min. A template should be used to ensure accuracy. The grounds are frequently connected with joint stays, and these are an advantage, as they strengthen the job and facilitate the withdrawal of the parts from their mould. On the joint of one half pattern it is advisable to draw the sectional shape of the casting and, although it is not necessary to entirely fill in between the stays, sufficient surface should be formed to draw the thicknesses and show the connecting ribs. The core prints attached to each end should be reasonably thick, about 3 in., and may be cut from solid timber, though a plate with segments to make up the thickness will answer quite well.

With regard to the cores, some foundries prefer core-boxes for this type of piston valve, a half box for the steam passage and a full box for the valve rod chamber, but the core or the steam passage can be made quite well from a framed plate and the centre core may be swept horizontally with the aid of a profiled edged board. The latter method is the more common practice, though there is much to be said for the use of core-boxes when a few similar castings are required; this, however, is not frequently the case. We will therefore confine ourselves to the consideration of a suitable plate. Such a framed plate is shown in Fig. 7. It consists of a framed baseplate about 1¼ in. thick, having an internal shape corresponding to the contour of the required core. Grounds are secured at each end to complete the half diameter of the core prints and a half pattern of the centre chamber with prints extending to the grounds is set in the frame, together with the requisite ribs. Many patternmakers prefer to make the baseplate solid, using the top side as the centre. This method is undoubtedly simpler in the patternshop, and the parts are more easily secured, but the framed plate facilities stripping in the foundry, the half core being made direct on a drying plate, from which a framed plate can be removed as soon as the core has been made. This is an advantage, even though the ribs and centre half barrel must be left in the core until it is dry enough to be moved. When the connecting ribs are straight the advantage of the framed baseplate to the foundry should be primarily considered, but, on the other hand, with curved ribs, the solid baseplate should be used because of the difficulty in locating the ribs on the joint of an open frame. Figs. 8 and 9 show the construction of a core frame with a solid baseplate when curved ribs are required in the casting, while Fig. 7 illustrates the open frame for straight ribs. In either case the ribs on the joint can be readily withdrawn when the half core is lifted, but the other ribs at the top should be jointed and dowelled in the manner shown in Fig. 10, in order that they can be readily withdrawn from the core. A top bar is, therefore, necessary to fix these ribs. The half cores will be exactly similar when straight ribs are used, and also where the ribs are curved, so that it will not be necessary to change the joint ribs in either case. The centre piece for the core plate is generally turned, though only half is required. The method certainly involves a waste of material, but this is more than compensated for by the saving in time of making the part and the greater accuracy that is obtained when it is turned. Sometimes the centre shape is made up skeleton fashion, but this method is not recommended, unless in extremely urgent cases when time is a very important factor.

We have considered the prevailing practice in preparing the pattern work for piston valves that are relatively long, but in many cases similar types of valves are comparatively short, although the diameters may be similar to those of the longer kind. Because of this change in length the procedure frequently adopted differs from that already referred to and, consequently, a brief reference should be made to this alternative method. Many moulders prefer to prepare a mould in the direction it is to be cast, and there are advantages in adopting this practice with piston valves, the principal one being that there is less danger of any movement of the cores due to turning the mould. The method involves a middle part when moulding, and the core must be jointed in a plane at right-angles to the valve spindle. The altered method of moulding makes a considerable difference in the form of pattern work supplied. The jointing of such a pattern is indicated in Fig. 11, and it will be noted that each section is built segmentally, a method which is suitable for the shorter pieces required, as not only is such a pattern less likely to alter its shape, but spigots and socket are readily turned for locating the difficult sections. For the core a plate, such as is shown in Fig. 12, is generally used, made to suit the longest part of the core and provided with stopping-off pieces for the other part. The outside shape of the core is swept, but it is necessary to locate the centre barrel accurately and maintain its vertical position, therefore a framed bar should be secured to the plate and brackets used to hold it vertical, in order that the top of the barrel can be secured. The ribs may be jointed, as in Fig. 10, the inside parts being housed into the barrel to which vertical bars are secured to the plate to which the outer parts of the ribs can be secured. The stiffening bars and ribs have been purposely omitted from the sketch so that the principle of the construction may be more easily grasped.

French Metallurgist Honoured.

Monsieur Léon Guillet has been elected a member of the Academie des Sciences. He replaces Professor Rabut in the section which deals with the application of science to industry Mons. Guillet is the director of the Ecole Centrale and has achieved a world-wide fame as a scientific metallurgist. He is a doctor of science and a past president of the Société des Ingenieurs Civils.

Trade Talk.

THE FRENCH LONGOVICIA have booked an order for 5,000 tons of rails for the Egyptian railways.

THE BLASTFURNACE at Oldside, near Workington, of the United Steel Companies, Limited, was damped down last Tuesday week.

ON COMPLETION of 50 years' service with J. Hopkinson & Company, Limited, Huddersfield, two of the firm's oldest employees were each presented with £50 on July 16.

THE PETITION of the Charcoal Iron Company, Limited, for a compulsory winding-up of John Crowley & Company, Limited, ironfounders, Sheffield, was granted by Mr. Justice Eve on Wednesday.

BURNEY & BLACKBURNE, LIMITED, Ripaults, Limited, the Newcastle-upon-Tyne Electric Supply Company, Limited, Stephenson Clarke & Company, Limited, and Spear & Jackson, Limited, have been elected members of the Federation of British Industries.

THE EGYPTIAN RAILWAYS have placed an order for 15 locomotives, at the price of £5,930 each, with German firms. Since rapid delivery was asked for, with which German firms were unable to comply, the North British Locomotive Company, Limited, have also secured an order for over 35 locomotives, though higher prices were quoted.

THE SYDVARANGER COMPANY, the Norwegian iron ore concern, has issued a statement to the effect that it was compelled to suspend payment temporarily, pending the decision of the Supreme Board, but it is unlikely that there will be a complete stoppage in the near future. During the past six months the company exported 250,000 tons of ore.

MR. E. POTTER, Lonsdale Chambers, 27, Chancery Lane, London, W.C.2, informs us that a bill which is expected to become law at an early date is now before the Irish Free State Parliament in connection with the granting of letters patent and the registration of designs and trade marks. Previously British patents have extended to the Irish Free State, but under the new bill patents in Ireland, other than Northern Ireland, will be distinct and separate from British patents, and separate applications will have to be filed. Provision is made for extending British patents, designs and trade marks to the Irish Free State.

THOS. W. WARD, LIMITED, of Sheffield, who have broken up many old works, have purchased the Mars Ironworks for the purpose of dismantling. The firm of George Adams & Sons, Limited, Mars Ironworks, Wolverhampton, was established in 1867 by George Adams, Richard Morris and Abraham Bennett. This partnership was dissolved in 1874, and the business was continued as George Adams until 1879, when the title was changed to George Adams & Sons. In 1894 the business was turned into a private limited company under its present style. The firm has won a high reputation in home and foreign markets for their iron and steel sheets, hoops, bars and galvanised sheets, and their trade mark, the figure of Mars, is world famous.

Institute of Metals.—The following papers are to be read at the meeting of this Institute at Glasgow on September 2 and 3, 1925:—(1) "The Effect of Low-Temperature Heating on the Release of Internal Stress in Brass Tubes," by Robert J. Anderson and Everett G. Fahlman; (2) "Colloidal Separations in Alloys," by Professor J. H. Andrew and Robert Hay; (3) "The Influence of the Time Factor on Tensile Tests Conducted at Elevated Temperatures," by John S. Brown; (4) "Passification and Scale Resistance in Relation to the Corrosion of Aluminium Alloys," by L. H. Callendar; (5) "Zinc-Cadmium Alloys. A Note on their Shear Strengths as Solders," by R. B. Deeley; (6) "Thermal Conductivities of Industrial Non-Ferrous Alloys," by J. W. Donaldson; (7) "The Influence of Pouring Temperature and Mould Temperature on the Properties of a Lead-Base Anti-Friction Alloy," by Professor O. W. Ellis; (8) "On the Constitution of Zinc-Copper Alloys containing 45 to 65 per cent. of Copper," by Marie L. V. Gayler; (9) "The Effect of Temperature on the Behaviour of Metals and Alloys in the Notched-Bar Impact Test," by R. H. Greaves and J. A. Jones; (10) "On the Constitution of Alloys of Aluminium, Copper, and Zinc," by D. Hanson and Marie L. V. Gayler; (11) "The Beta Transformations in Copper-Zinc Alloys," by J. L. Haughton and W. T. Griffiths; (12) "The Properties of Some Aluminium Alloys," by Harry Hyman; (13) "The High-Temperature-Tensile Curve. (*a*) Effect of Rate of Heating. (*b*) Tensile Curves of Some Brasses," by Douglas H. Ingall; (14) "The Physical Properties of the Copper-Cadmium Alloys Rich in Cadmium," by C. H. M. Jenkins; (15) "The Primitive Copper Industry of America," by George Brinton Phillips; (16) "The Alpha-Phase Boundary in the Copper-Tin System," by D. Stockdale.

Company News.

Widnes Foundry (1925), Limited, Widnes Foundry, Widnes.—Capital £35,000 in £1 shares.

William Green (Leeds), Limited.—Capital £5,000 in £1 shares. Engineers. Directors: B. Green, 173 Hunslet Road, Leeds; and Mrs. K. Green.

James Lamont & Company, Limited. — Capital £25,000 in £1 shares. Engineers. Directors: A. T. Lamont, 3, Dock Breast, Greenock; and Mrs. Martha Lamont.

Boghead Steel Foundry and Engineering Company, Limited.—Capital £5,000 in £1 shares. Directors: W. Hamilton, Windsor Cottage, Bathgate, and R. Calderwood.

Effingham Steel Works, Limited.—Capital £70,000 in £10 shares. Directors: H. F. Marsh, Brown Grove House, Sheffield; H. T. Bradbury, J. P. Marsh, W. L. Marsh, and L. Brittain.

B. Wright & Son, Limited.—Capital £10,000 in £1 shares (5,000 6 per cent. cumulative preference and 5,000 ordinary). Engineers. Directors: B. Wright, Oak Lea, Stainbeck Lane, Leeds; and J. Wright.

Mond Nickel Company, Limited.—The eleventh annual meeting was held on July 9 in London. The RIGHT HON. SIR ALFRED MOND, BT., chairman of the company, presided. Two non-ferrous metals which they manufactured, nickel and copper, were, in comparison with pre-war figures, still on a very low basis, he said. The average price of nickel before the war was about £160, and the list price to-day was £170. The price of copper was unquestionably low in comparison when one took into account post-war costs and pre-war costs, so that in their two main products the proceeds of manufacture were really low in comparison with what they ought to be in view of the general increase in costs both in Canada and here owing to the war. On the whole, the position of the nickel industry was healthier than it had been in the past. The uses of nickel as a metal were expanding in every direction, and were likely to expand still further, owing to the invention of new compounds possessing remarkable qualities of non-corrosion, electrical conductivity, and the power to stand at very high temperatures pressure and tensile tests quite unheard of formerly, all tending to make nickel a metal the use of which was bound to go on increasing in the electrical and engineering worlds.

General Electric Company, Limited.—SIR HUGO HIRST, BT., who presided at the annual meeting of this company, said:—Our exports, amounting to several millions, are much more valuable exports than those of much bigger concerns who must, by the nature of their business, rely largely on importation, and whose exports leave this country merely a commission. While the country imports over 500 millions worth of essential foodstuffs, the quality of our exports, which have to pay for such importation, plays an important part. Our contribution to taxation and public services of various kinds cannot be much less than a quarter of a million, and the fact that our wages and salary bill must amount to something between three and four million pounds a year, means a considerable contribution to the purchasing power of the people of this country. These general and national interests weighed heavily with us in all our decisions. We have done away with items in the balance-sheet that need not be dealt with again. We have by no means arrived at the limit of our possibilities. Though this company was formed in 1889 with a capital of £30,000 and has to-day a capital of £9,000,000, I feel as much as ever that, electrically speaking, we are only at the beginning of things. The supply of electricity in the London area by some 70 or 80 authorities has involved a capital expenditure of over 30 millions. If the engineers of this company were given the chance of a modern lay-out of one big power station, we could, for less than half that capital, give a bigger output at a considerably reduced cost of production. This is just an indication of what will happen sooner or later to 90 per cent. of the existing power stations in the country. You can imagine how reduced cost of production will stimulate the application of electrical apparatus in industrial and private service. Official figures were presented at last year's World Power Conference, showing that the lamps per head of population used in U.S.A. are 1.74, in Switzerland 1.62, Germany 0.88, France 0.72, and in the United Kingdom 0.42. The improvement of lamps and the study of better lighting methods have led to a considerable increase in the use of electric light during the last few years, and I am satisfied that the combined efforts of the industry to educate the public in the proper use of lighting, how to light houses, shops, streets, and factories, will mean a considerable growth of this industry, in which we hold an important place.

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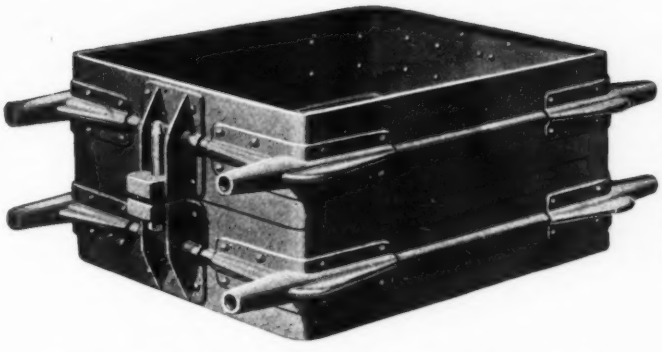

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Influenced to some extent, doubtless, by the uncertainty of the outcome of the crisis in the mining industry, the position of the Cleveland iron trade at the moment may be best described as quietly steady, with buying mostly confined to moderate sized parcels sufficient in tonnage to carry over to the conclusion of the approaching holidays. Consumers, while agreeing that present prices are reasonable, do not believe that any advance is likely, and accordingly limit their commitments. Export trade is also quiet, and the improvement in inquiry noted recently has apparently fallen off again. The price of No. 3 G.M.B. now stands at 71s. No. 1 is quoted at 75s., No. 4 foundry about 70s. 6d., and No. 4 forge in the region of 70s. per ton.

Inquiries for hematite on home account have assumed a more active tendency of late, but the trouble is that the demand generally represents only a very small volume of business. There is a report, as yet unconfirmed, that a sale of low phosphorus hematite has just been made to America. The quotation for East Coast mixed numbers is maintained at 77s. per ton, but this is a more or less nominal figure, as it can be broken without difficulty by buyers with a firm offer for a good-sized parcel. In the North-West area, prices are unchanged, Bessemer mixed numbers being quoted at £4 5s. c.i.f. Welsh ports, £4 8s. per ton delivered at Glasgow, £4 12s. 6d. per ton delivered at Sheffield, and £4 15s per ton delivered at Birmingham.

LANCASHIRE.—The iron foundry trade in this district is without improvement, and any small demand for pig-iron that may exist is not due to more orders for castings. Sellers of Derbyshire No. 3 generally base their quotations upon 70s. per ton at the furnaces, although there are some who now try for a little more. There is some Lincolnshire No. 3 offering at the same price as Derbyshire, viz., 77s. 6d. per ton delivered in Manchester, and Northamptonshire iron might be bought at the same price.

THE MIDLANDS.—Consequent upon the threatening aspect of the position in the mining industry foundry pig consumers in this area appear more inclined to secure supplies than has been the case for some time past, and prices have accordingly firmed up to a slight extent. Current quotations now rule as follow :—Derbyshire No. 3 foundry, 70s. ; Staffordshire No. 3 foundry, 72s. 6d. ; Northants No. 3 foundry, 65s.

SCOTLAND.—The celebration of the annual summer holiday in the North now in progress has led to an entire suspension of market business, with prices nominally unchanged at 81s. 6d. for No. 3 Scotch foundry at the furnaces, and 75s. for No. 3 Middlesbrough, at Grangemouth. In spite of the labour troubles on the Continent, and the reduction in the number of furnaces operating there, Continental foundry iron is a shade easier at 68s. at Grangemouth.

Finished Iron.

Although by no means in a condition of normal activity, manufacturers of finished material report a slight improvement in demand for the better grades of iron, and also more inquiry for Crown quality, but it is chiefly in connection with marked bars and tested irons that increased interest is discernible. There is no alteration in prices, marked bars being £14 10s. at works, and although crown iron is officially quoted at £12 7s. 6d., it can be obtained at 2s. 6d. less from works outside the Association. None of the works are running full time, and the makers of nut and bolt and fencing-iron are very badly off for work, for it is in connection with this quality of iron competition is experienced with the low prices for the Continental products. Belgian and French houses are offering iron bars, delivered South Staffordshire at figures varying from £6 11s. to £7, and with the local price in the neighbourhood of £11 7s. 6d., it will be seen that the bulk of the available business must of necessity go abroad.

Steel.

At Sheffield business in most branches of the steel industry continues quiet, but more railway work is coming to hand in the district, file makers are receiving good Russian orders, and the shipbuilding contracts for Cammells and Browns can hardly fail to help local business to some extent. In the market for semis conditions are slightly improved. Siemens acid billets from 0.25 to 0.85 per cent. carbon have been reduced from £11 to £10 10s., but under 0.25 carbon the quotation will continue to be £11. With the object of meeting the extremely fierce competition from the Continent there has been a sharp cut in wire rod prices. Acid steel rods are now £16 per ton instead of £18. Medium basic wire rods, which have stood at £13 15s. per ton, are down to £12 5s. per ton for under 50 tons, and to £11 15s. for 50 tons and over. Hard basic rods have been brought down from £15 to £14 for under 50 tons, and to £13 10s. for 50 tons and over. Tinplates have been done down to 18s. 9d. basis I.C., f.o.b. works port, but, generally, makers are not disposed to accept this low figure, and the price may be called 19s. to 19s. 3d. basis.

Scrap.

Reports from the various markets for scrap material indicate almost without exception the continuance of stagnation of business previously noted, and so far without hopes of any immediate prospect of relief from the prevailing depression. In Lancashire, for example, buying on foundry account is reduced to a minimum, with prices weaker. In this district there is a good deal of common cast scrap, and a fair quantity of good broken machinery in the market, but special "textile" scrap, or broken cast iron from looms, is scarce, and holders can get 82s. 6d. per ton for it. The price of ordinary cast scrap varies from 72s. 6d. to 77s. 6d. per ton, according to quality, delivered free to the foundries. In South Wales heavy cast iron in large pieces and furnace sizes is not active, and is offered at 65s. to 67s. 6d. Good machinery scrap in foundry sizes has a weak market at 70s. to 72s. 6d.

Metals.

Copper.—Movements in the standard market of late have developed a more active tendency, while values have also been distinctly firmer, both on cash and three months' account. The belief is gaining ground that the metal will experience a substantial advance before the year expires, and the firm advices received from America have already been responsible for an upward move. Current quotations :—*Cash* : Thursday, £62 5s. ; Friday, £61 12s. 6d. ; Monday, £61 5s. ; Tuesday, £61 17s. 6d. ; Wednesday, £61 12s 6d.

Three Months : Thursday, £63 5s. ; Friday, £62 12s. 6d. ; Monday, £62 5s. ; Tuesday, £62 17s. 6d. ; Wednesday, £62 12s. 6d.

Tin.—Movements in tin also have taken a further upward trend, with values advanced substantially since last reported, the outlook being regarded as favourable to still higher prices being established in the near future. Supplies, generally speaking, are only moderate, and there does not seem much prospect of any improvement in this respect for some time to come. Current quotations : — *Cash* : Thursday, £263 7s. 6d. ; Friday, £253 15s. ; Monday, £257 7s. 6d. : Tuesday, £258 15s. ; Wednesday, £261.

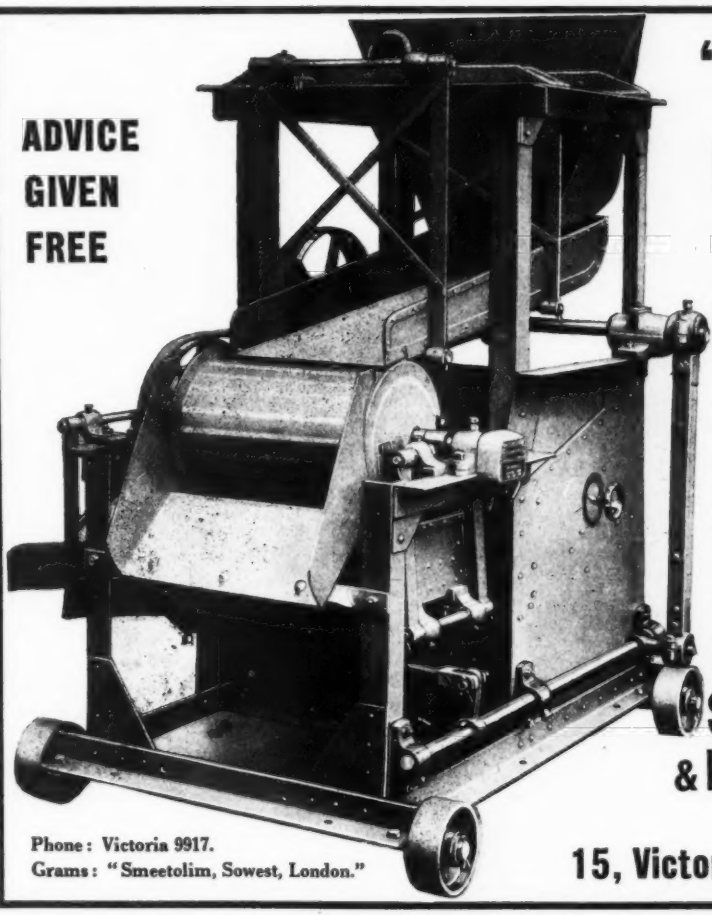
Three Months : Thursday, £266 ; Friday, £261 7s. 6d. ; Monday, £260 ; Tuesday, £261 12s. 6d. ; Wednesday, £263 12s. 6d.

Spelter.—The market for this metal, though business is generally quiet, continues firm, with values advancing in sympathy with similar movements in other sections. Sentiment is certainly more bullish than it has been for some time, but the principal consuming industries are not showing any greater activity. Current quotations : — *Ordinary* : Thursday, £35 12s. 6d. ; Friday, £35 2s. 6d. ; Monday, £35 2s. 6d. ; Tuesday, £35 5s. ; Wednesday, £35 8s. 9d.

Lead.—Soft foreign pig has been in fair demand, supplies coming forward being mostly readily absorbed on home account. One of the Australian shipping firms is understood to have effected a settlement of the dispute with its men, but in other cases the strike is being continued, although there are good prospects of an all-round settlement Current quotations :—*Soft foreign (prompt)* : Thursday, £35 7s. 6d. : Friday, £35 ; Monday, £35 2s. 6d. ; Tuesday, £35 12s. 6d. ; Wednesday, £36.

Tata Company's Output.—According to a report published in the "Times of India," the two new furnaces of the Tata Iron and Steel Co., at Jamshedpur, atttained daily outputs as high as 636 and 672 tons of pig-iron per day respectively during January. The most notable feature of the report is that the high efficiency of the two furnaces was achieved with low-grade fuel, and the fixed carbon consumed per ton of pig-iron was only 1,593 lbs. The D furnace was first blown in on December 5, 1922, and the C furnace on January 17, 1924. The operating data for these two furnaces during January are as follow :—

	C.	D.
Pig-iron produced, in tons	17,414	17,676
Average per day, in tons	561.74	570.19
Highest day, in tons	636	672
Average weight of coke, in lbs. per ton	2,102	2,200



ADVICE GIVEN FREE

"STEINERT"
(PATENT)
MAGNETIC IRON SEPARATORS

Will separate Iron and Steel from all kinds of material.

"Steinert" Separators are made in all sizes and for all capacities from one ton per hour and upwards.

Send us your problems and let us quote you for a separator designed to suit your own requirements.

THE BRITISH SCHURMANN CUPOLA & FOUNDRY EQUIPMENT CO., LTD.,

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Phone: Victoria 9917.
Grams: "Smeetolim, Sowest, London."

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Wm. ROBERTS & SON.

Best Qualities

BEEHIVE and PATENT OVEN FOUNDRY and FURNACE COKES,

GANISTER,

LIMESTONE,

FIRE-CLAY GOODS, &c.

Telephone No. Bury 560.

FOUNDRY COKE FACTORS

6, Garden Street BURY, Lancs.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	61	12	6
Three months	62	12	6
Electrolytic	66	5	0
Tough	63	0	0
Best selected ..	63	10	0
Sheets	91	0	0
India	80	10	0
Wire bars ..	67	0	0
Do. Aug–Sept.	66	10	0
Do. Aug–Sept.	66	10	0
Ingot bars ..	66	10	0
H.C. wire rods	70	0	0
Off. av. cash, June	59	19	2 3/7
Do., 3 mnths., June	60	18	9
Do. Sttlmnt, June	59	18	9 1/2
Do., Electro, June	63	11	5 1/2
Do., B.S., June	63	1	11 1/2
Aver. spot price copper, June	59	19	2 3/4
Do., wire bars, June	63	15	5 1/2
Solid drawn tubes			13d.
Brazed tubes ..			13d.
Wire			9 3/4d.

BRASS.

Solid drawn tubes	11 3/4d.
Brazed tubes ..	13 1/2d.
Rods, drawn ..	10 1/2d.
Rods, extd. or rlld.	7 1/2d.
Sheets to 10 w.g.	10 1/2d.
Wire	10 1/2d.
Rolled metal ..	9 1/2d.
Yellow metal rods	7 1/2d.
Do. 4 x 4 Squares	8d.
Do. 4 x 3 Sheets	8 1/2d.

TIN.

Standard cash	261	0	0
Three months .	263	12	6
English ..	261	0	0
Bars	261	0	0
Straits	264	10	0
Australian .	261	15	0
Eastern ..	265	0	0
Banca	264	15	0
Off. aver. cash, June	252	11	8
Do., 3 mths., June	253	19	8 3/7
Do., Sttlmnt. June	252	12	7 3/7
Aver. spot., June	252	11	8

SPELTER.

Ordinary ..	35	8	9
Remelted ..	35	0	0
Hard	29	0	0
Electro 99.9 ..	40	5	0
English ..	35	15	0
India	30	10	0
Zinc dust ..	42	0	0
Zinc ashes ..	14	10	0
Off. aver., June	33	17	4 13/14
Aver., spot, June	34	2	11 3/4

LEAD.

Soft foreign ppt.	36	0	0
English ..	37	5	0
Off. average, June	33	4	6 9/14
Average spot, June	33	9	7

ZINC SHEETS, &c.

Zinc sheets, English	41	0	0
Do. V.M. ex whf.	40	0	0
Dutch			—
Rods	46	0	0
Boiler plates ..	41	0	0
Battery plates	39	0	0

ANTIMONY.

Special brands, Eng.	84	10	0
Chinese ..	65	0	0
Crude	53	0	0

QUICKSILVER.

Quicksilver ..	14	0	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro silicon 45/50% ..	13	0	0
75%	22	5	0
Ferro-vanadium— 35/40%	16/6 lb. va		
Ferro-molybdenum— 70/75% c. free	7/– lb.		
Ferro-titanium— 23/25% carbonless	1/–lb		
Ferro-phosphorus, 20/25%,	£22	0	0
Ferro-tungsten— 80/85 %, c.fr.	1/6 to 1/7 lb.		
Tungsten metal powder— 98/99%	1/9 to 1/11 lb.		
Ferro-chrome— 4/6% car. ..	£23	10	0
6/8% car. ..	£23	0	0
8/10% car. ..	£22	10	0
Ferro-chrome— Max. 2% car.	£42	10	0
Max. 1% car.	£52	0	0
Max. 0.70% car.	£56	10	0
70%, carbonless	1/5 lb.		
Nickel—99%, cubes or pellets	£170 to £175		
Cobalt metal—98/99%	10/– lb		
Aluminium 98/99%	£118		
Metallic Chromium— 96/98% ..	3/9 lb.		
Ferro-manganese (net)— 76/80%, loose	£15	10	0
76/80%, packed	£16	10	0
76/80%, export	£15	0	0
Metallic manganese— 94/96%, carbonless	2/–lb.		
Per ton unless otherwise stated.			

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten ..	s. d. 2 6
Finished bars, 18% tungsten ..	3 0
Per lb. net, d/d buyers' works.	
Extras— Rounds and squares 3 in. and over ..	4d. lb.
Rounds and squares under ½ in. to ¼ in.	3d. lb.
Do. under ¼ in. to ⅛ in.	1/– lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do. under ½ in. × ¼ in.	1/– lb.
Bevels of approved sizes and sections	6d. lb.
Bars cut to length	10% extra
Scrap from high-speed tool steel —	
Scrap pieces ..	3d.
Turnings and swarf	1d.
Per lb. net, d/d steel makers' works.	

SCRAP.

South Wales—	£	s.	d.	£	s.	d.
Hvy, steel	3	3	6 to 3	5	0	
Bundled steel &shrngs.	3	0	0 to 3	2	6	
Mixed iron & steel	2	17	6 to 3	0	0	
Heavy cast iron	3	5	0 to 3	7	6	
Good machinery for foundries	3	10	0 to 3	12	6	
Cleveland— Heavy steel ..	2	17	6			
Steel turnings ..	2	4	6			
Cast-iron borings	2	0	0			
Heavy forge ..	4	0	0			
Bushelled scrap	3	5	0			
Cast-iron scrap	3	11	0 to 3	11	6	
Lancashire— Cast-iron scrap ..	3	12	6			
Heavy wrought	3	12	6 to 3	15	0	
Steel turnings ..	2	5	0			

London — Merchants' buying prices delivered yard.

Copper (clean) ..	53	0	0
Brass (clean) ..	40	0	0
Lead (less usual draft)	31	0	0
Tea lead ..	27	0	0
Zinc	24	0	0
New aluminium cuttings ..	93	0	0
Braziery copper	48	0	0
Gunmetal ..	48	0	0
Hollow pewter ..	178	0	0
Shaped black pewter	130	0	0

PIG-IRON.

(f.o.t. unless otherwise stated).

N.E. Coast—	
Foundry No. 1 ..	75/–
Foundry No. 3 ..	71/–
Foundry No. 4 ..	70/6
Forge No. 4 ..	70/–
Hematite No. 1 ..	77/6
Hematite M/Nos. ..	77/–
N.W. Coast—	
Hem. M/Nos. d/d Glas.	88/–
,, d/d Birm. ..	95/–
Midlands—	
Staffs. common* ..	102/–
,, No. 4 forge	68/9
,, No. 3 foundry	72/6
Shrops. basic ..	85/–
,, Cold blast, ord.*	190/–
,, ,, roll iron*	195/–
* d/d Birmingham.	
Northants forge ..	59/–
,, fdry No. 3 ..	65/–
Derbyshire forge ..	65/–
,, fdry No. 3 ..	70/–
,, basic	72/6
Scotland—	
Foundry No. 1 ..	86/6
,, No. 3 ..	81/6
Hem. M/Nos. ..	83/6
Sheffield (d/d district)—	
Derby forge ..	70/–
,, fdry. No. 3 ..	74/–
Lincs. forge ..	—
,, fdry. No 3 ..	78/–
E.C. hematite ..	87/–
W.C. hematite ..	92/6
Lincs. (at furnaces)—	
Forge No. 4 ..	—
Foundry No. 3 ..	72/–
Basic	72/–
Lancashire (d/d eq. Man.)—	
Derby forge ..	73/–
,, fdry. No. 3 ..	77/6
Northants foundry No. 3 ..	78/–
Dalzell, No. 3 ..	111/6
Summerlee, No. 3 ..	99/–
Glengarnock, No. 3	99/–
Gartsherrie, No. 3 ..	99/–
Monkland, No. 3 ..	99/–
Coltness, No. 3 ..	99/–
Shotts, No. 3 ..	99/–

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	11	12	6 to 12	10	0	
Angles		12	7	6		
Tees to 3 united ins		13	2	6		
Nut and bolt		11	15	0		
Hoops	14	0	0 to 15	0	0	
Marked bars (Staffs.) f.o.t.		14	10	0		
Gas strip ..		13	0	0		
Bolts and nuts, ¾ in. × 4 in. ..		16	15	0		
Steel—						
Ship plates	8	15	0 to 9	0	0	
Boiler plts.	£12	10	to 13	0	0	
Chequer plts.	£10	10	to 11	0	0	
Angles	£8	0	0 to 8	7	6	
Tees	£9	0	0 to 9	7	6	
Channels	£7	10	0 to 8	0	0	
Joists	£8	0	0 to 8	7	6	
Rounds and Squares 3in. to 5½in. ..		9	5	0		
Rounds under 3 in. to ¾ in... ..		9	0	0		
Flats, over 5 in. wide and up ..		9	15	0		
Flats, 5in. to 1½in.		8	15	0		
Rails, heavy ..		8	10	0		
Fishplates ..		12	10	0		
Hoops (Staffs.)	£11	0	0 to 11	10	0	
Black sheets, 24g.		11	10	0		
Galv. cor. sheets, 24g.		16	0	0		
Galv. fencing wire 8g. plain ..		14	0	0		
Billets, soft	6	10	0 to 7	15	0	
Billets, hard ..		9	0	0		
Sheet bars	6	12	6 to 6	15	0	
Tin bars d/d	6	12	6 to 6	15	0	

PHOSPHOR BRONZE

	Per lb.	basis.
Strip	1	3
Sheet to w.g. ..	1	3½
Wire	1	3¾
Rods	1	2½
Tubes	1	8
Castings	1	2

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb. basis.
Ingots for raising	9d. to 1/3
Rolled— To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/– to 1/8½
Wire round— 3/0 to 10 G. ..	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	21.26
No. 2 foundry, Valley	20.26
No. 2 foundry, Birm.	18.00
Basic	19.76
Bessemer	20.76
Malleable	20.26
Grey forge	19.76
Ferro-mang. 80% d/d	115.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess. billets	35.00
O.-h. billets	35.00
O.-h. sheet bars ..	35.00
Wire rods	45.00
	Cents.
Iron bars, Phila. ..	2.22
Steel bars	2.00
Tank plates	1.90
Beams, etc.	2.00
Skelp, grooved steel ..	1.90
Skelp, sheared steel ..	1.90
Steel hoops	2.40
Sheets, black, No. 28 ..	3.10
Sheets, galv., No. 28 ..	4.20
Sheets, blue an'l'd,9 & 10	2.30
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv. ..	3.40
Tinplate, 100 lb. box ..	$5.50

COKE (at ovens).

Welsh foundry ..	37/6
,, furnace	27/6
Durham & North. ,, foundry ..	35/–
,, furnace ..	17/6
Other Districts, foundry	35/–
,, ,, furnace (Basis)	13/6

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes, 20 × 14, box		19/3
,,	28 × 20, ,,	38/6
,,	20 × 10, ,,	27/9
,,	18¾ × 14, ,,	19/10½
C.W.	20 × 14, ,,	17/3
,,	28 × 20, ,,	34/6
,,	20 × 10, ,,	24/3
,,	18¾ × 14, ,,	17/10½

Terneplates 28 × 20, 1/3 per box basis below tinplates.

SWEDISH IRON.

Bars, hammered	£19/0 to £20/0
Rolled Ord.	£16/0/0 to £16/10/0
Nail rods	16 5 0 to £16 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£10 to £14
Pig-iron	£6 15 0 to £7 0 0

all f.o.b. Gothenburg.

TUBES.

Up to and incl. 6 in.

Gas .. 55% } Tube prices
Water .. 50% } are
Steam .. 45% } now free.

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.	
July 23	62	5	0	No change
,, 24	61	12	6	dec. 12/6
,, 27	61	5	0	,, 7/6
,, 28	61	17	6	inc. 12/6
,, 29	61	12	6	dec. 5/-

Electrolytic Copper.

	£	s.	d.	
July 23	67	0	0	No change
,, 24	66	10	0	dec. 10/-
,, 27	66	0	0	,, 10/-
,, 28	66	10	0	inc. 10/-
,, 29	66	5	0	dec. 5/-

Standard Tin (cash).

	£	s.	d.	
July 23	263	7	6	inc. 12/6
,, 24	258	15	0	dec. 92/6
,, 27	257	7	6	,, 27/6
,, 28	258	15	0	inc. 27/6
,, 29	261	0	0	,, 45/-

Tin (English ingots).

	£	s.	d.	
July 23	263	10	0	inc. 15/-
,, 24	259	0	0	dec. 90/-
,, 27	258	0	0	,, 20/-
,, 28	259	0	0	inc. 20/-
,, 29	261	0	0	,, 40/-

Zinc Sheets (English).

	£	s.	d.	
July 23	41	0	0	inc. 20/-
,, 24	41	0	0	No change
,, 27	41	0	0	,, ,,
,, 28	41	0	0	,, ,,
,, 29	41	0	0	,, ,,

Spelter (ordinary).

	£	s.	d.	
July 23	35	12	6	dec. 1/3
,, 24	35	2	6	,, 10/-
,, 27	35	2	6	No change
,, 28	35	5	0	inc. 2/6
,, 29	35	8	9	,, 3/9

Lead (English).

	£	s.	d.	
July 23	36	10	0	No change
,, 24	36	5	0	dec. 5/-
,, 27	36	5	0	No change
,, 28	36	15	0	inc. 10/-
,, 29	37	5	0	,, 10/-

AVERAGE MONTHLY PRICES OF FERRO-MANGANESE (80 PER CENT.)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1914	9 12 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	11 0 0	12 5 0	11 6 3	10 7 6	10 7 6	9 10 8½
1915	11 0 6	12 10 0	14 10 0	15 0 0	17 15 0	20 0 0	20 0 0	20 0 0	20 0 0	20 0 0	20 0 0	20 0 0	17 11 3½
1916	20 0 0	22 10 0	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	52 0 0	25 0 0	25 0 0	25 0 0	23 10 10
1917	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0
1918	25 0 0	26 10 0	25 0 0	*	*	*	*	*	*	*	*	*	25 10 0
1919	*	*	*	*	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	24 10 0	23 0 0	25 10 0	24 14 3
1920	27 18 0	30 0 0	31 17 6	35 0 0	37 0 0	37 0 0	37 0 0	37 0 0	37 0 0	37 0 0	36 10 0	33 16 0	34 15 1½
1921	31 0 0	27 5 0	23 12 6	21 18 0	21 0 0	18 0 0	18 0 0	18 0 0	17 2 0	16 0 0	15 0 0	15 0 0	20 3 1½
1922	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	15 6 0	15 0 0	15 0 0	15 0 0	15 0 0
1923	15 0 0	15 0 0	16 0 0	17 5 0	18 0 0	18 0 0	18 0 0	18 0 0	18 0 0	17 15 0	17 0 0	17 0 0	17 1 8
1924	17 0 0	17 0 0	17 0 0	17 0 0	17 0 0	17 0 0	16 10 0	14 10 0	13 10 0	13 10 0	14 3 4	14 15 0	15 14 10½
1925	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 9 4½	—	—	—	—	—	—

* Not quoted.

AVERAGE MONTHLY PRICES PER UNIT OF MANGANESE ORE.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1914	10	9½	9½	9½	9.55	9½	9½	*	*	11.9	11.5	11.5	11.07
1915	1 0 3	1 2.63	1 4	1 4	1 8	1 9.88	1 10½	1 8.63	1 8	1 8	1 10.15	2 3.8	1 8.31
1916	2 7½	2 8	2 8	2 7½	2 6	2 6	2 6	2 6	2 7.6	2 8	*	*	2 7.08
1917													
1918			Prices pro	hibited.									
1919					2 1½	*	2 2¼	2 2.3	2 3.13	2 4.4	2 6½	2 7½	2 4.08
1920	2 11.8	3 6½	3 11½	4 1.8	4 5½	4 5½	4 3	4 1.13	4 0	3 9½	3 7½	2 10.7	3 10.19
1921	2 3.63	2 0½	1 8½	1 5.1	1 4½	1 2½	1 2½	1 2.13	1 1.7	1 2½	1 1.94	1 2.06	1 5.15
1922	1 1.63	1 1.44	1 1.1	1 1	1 1.25	1 1.7	1 2.31	1 2.13	1 2.1	1 2.13	1 2.63	1 2.95	1 1.86
1923	1 3.63	1 6.38	1 9.3	1 9½	1 10	1 10	1 9½	1 9	1 9	1 9.13	1 9	1 9¼	1 7.89
1924	1 10.88	1 11.2	1 11	1 11½	2 0	1 11½	1 11⅞	1 11	1 10½	1 10½	1 10	1 9¼	1 10.34
1925	1 9¼	1 10	1 10½	1 11	1 11	1 10½	1 9¼	—	—	—	—	—	—

* Not quoted.

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

18, BENNETTS HILL, BIRMINGHAM.

18, BENNETTS HILL, BIRMINGHAM.
11, OLD HALL STREET, LIVERPOOL.
EXCHANGE BLDGS., PORT TALBOT.
FOWLERS BUILDINGS, BOMBAY.
CLIVE STREET, CALCUTTA.
ANGAPPA NAICK STREET, MADRAS.

REGISTERED TRADE MARK

1, HONG KONG ROAD, SHANGHAI.
OCEAN BUILDING, SINGAPORE.
JAVA STREET, KUALA LUMPUR
5, SHAFFRAZ ROAD, RANGOON.
COX'S BUILDINGS, KARACHI.
P.O. BOX 1580, CAIRO.

PIG IRON

SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.,

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM COLVIN & COMPANY,

ROYAL EXCHANGE, MIDDLESBROUGH.

93, HOPE STREET, GLASGOW.

SMALL ADVERTISEMENTS.

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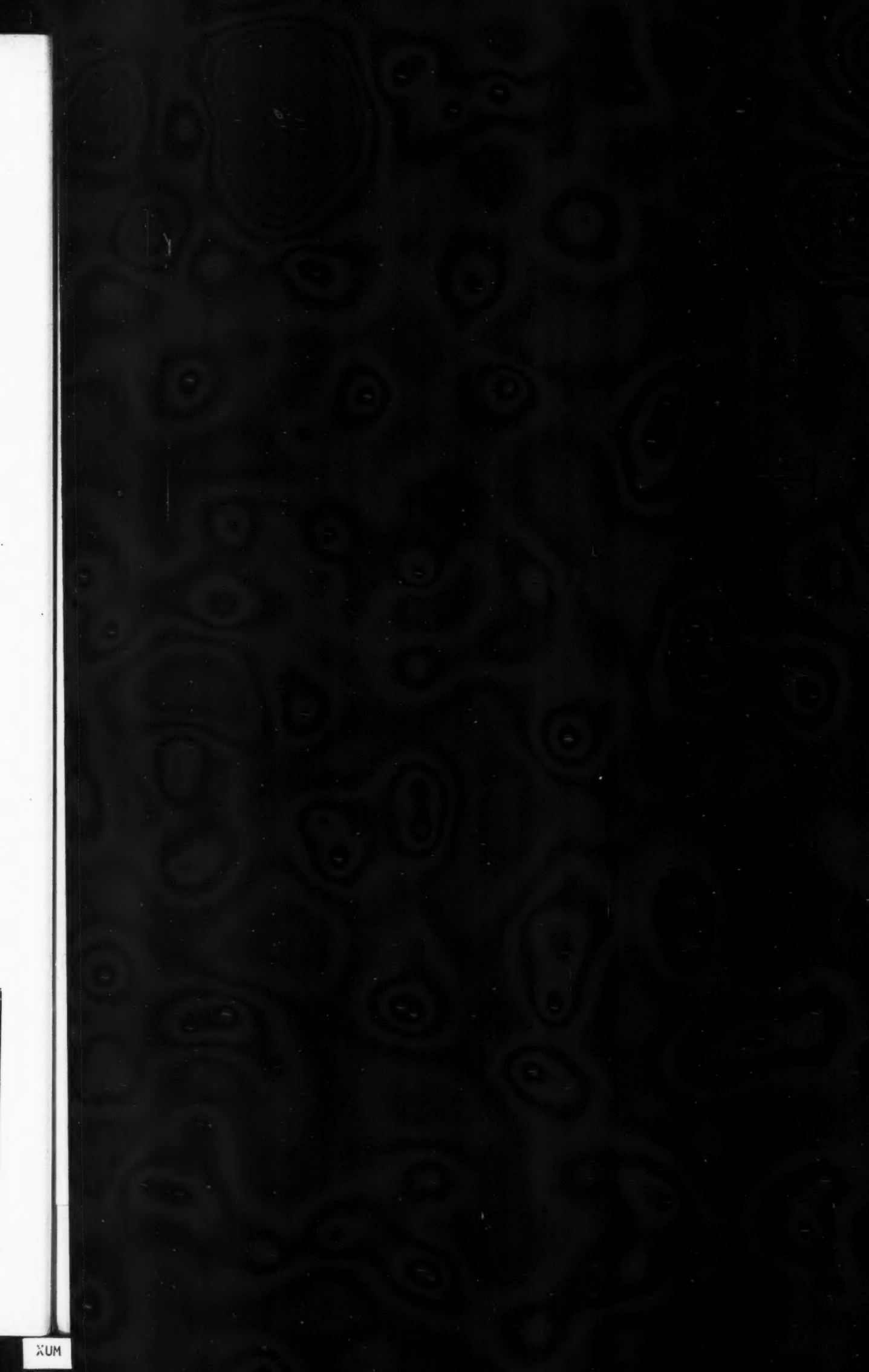
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